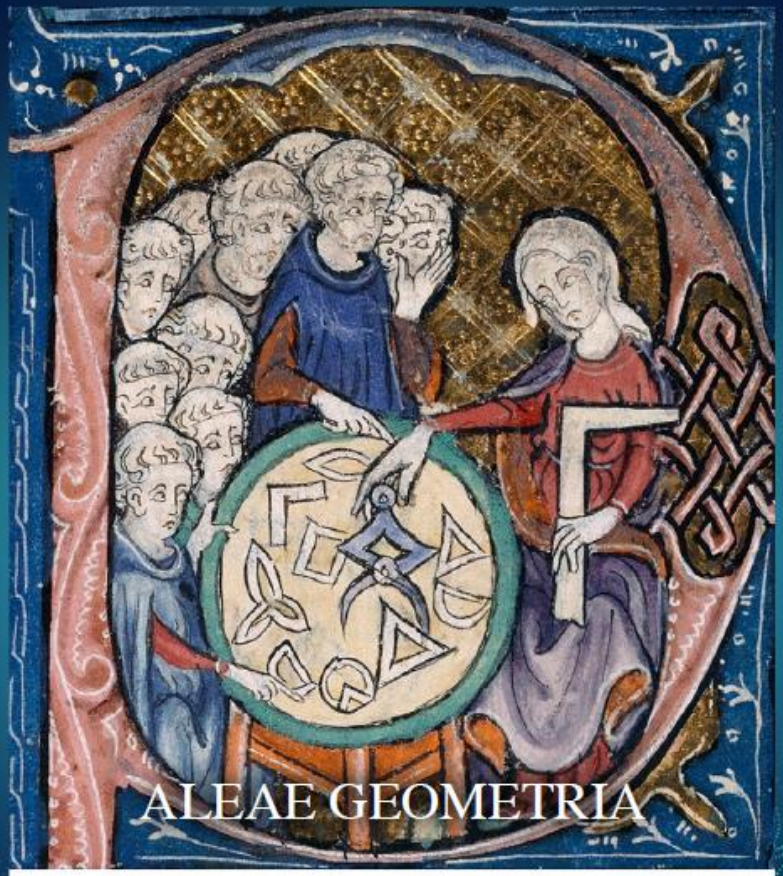
5th Conference on the Geometric Science of Information

GSI'21

Sorbonne University

July 21st – 22nd – 23rd 2021



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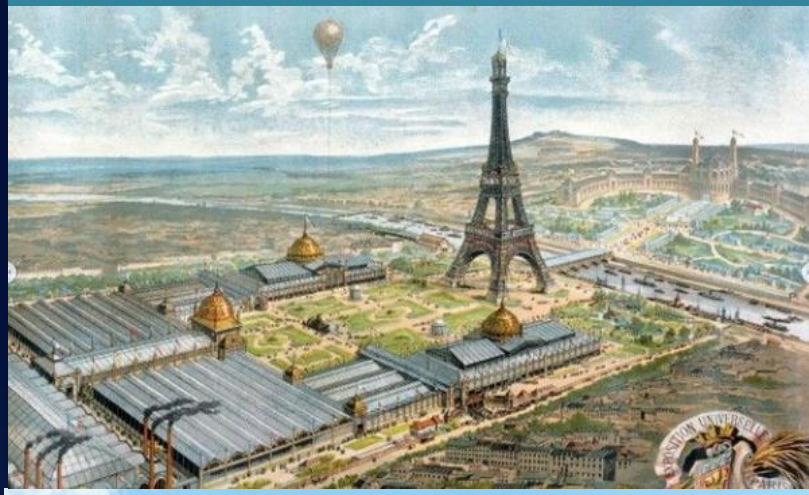
GSI'21

LEARNING GEOMETRIC STRUCTURES



Société de l'électricité, de l'électronique et des technologies de l'information et de la communication

Geometric Science of Information

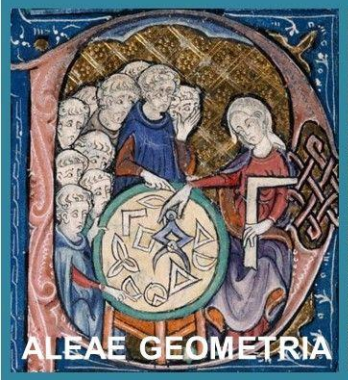
GSI'21 Conference, 21st-23rd July 2021

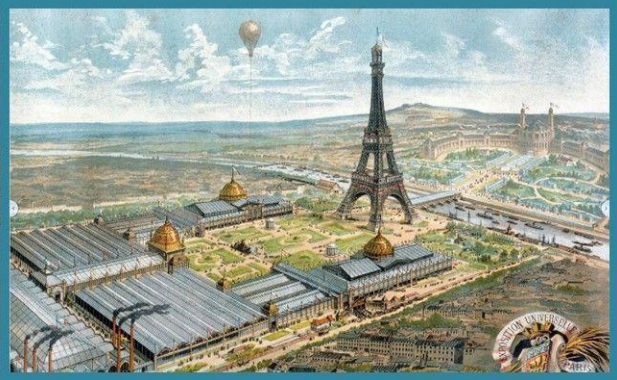
Sorbonne University, Paris

General Chairs: Frédéric BARBARESCO*, Frank NIELSEN**

(*) THALES, SEE ISIC Club President (Ingénierie des Systèmes d'Information & Communications)

(**) Sony CSL Tokyo





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LEARNING GEOMETRIC STRUCTURES

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GSI'21

5th GSI'21 Conference

LEARNING GEOMETRIC STRUCTURES

Sorbonne University

July 21st –22nd– 23rd 2021

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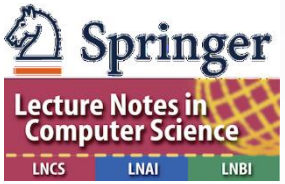

GSI'21 Editors & Organizer

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Editors

Organizer

SEE at a glance

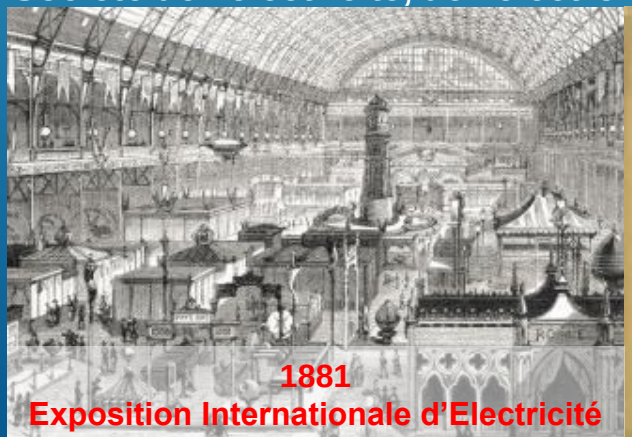
- Meeting place for science, industry and society
- An officialy recognised non-profit organisation
- About 2000 members and 5000 individuals involved
- Large participation from industry (~50%)
- 19 «Clubs techniques» and 12 «Groupes régionaux»
- Organizes conferences and seminars
- Initiates/attracts International Conferences in France
- Institutional French member of IFAC and IFIP
- Awards (Glavieux/Brillouin Prize, Général Ferrié Prize, Néel Prize, Jerphagnon Prize, Blanc-Lapierre Prize,Thévenin Prize), grades and medals (Blondel, Ampère)
- Publishes 3 periodical publications (REE, …) & 3 monographs each year
- Web: **http://www.see.asso.fr** and LinkedIn SEE group
- SEE Presidents: Louis de Broglie, Paul Langevin, …

Paul Langevin

Louis de Broglie

1883-2021: From SIE & SFE to SEE: 138 years of Sciences

Société de l'électricité, de l'électronique et des technologies de l'information et de la communication


1881
Exposition Internationale d'Electricité

1883: SIE
Société Internationale des Electriciens

1886: SFE
Société Française des Electriciens

2013: SEE
17 rue de l'Amiral Hamelin
75783 Paris Cedex 16

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scai.sorbonne-universite.fr

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Facts & Figures and Actions

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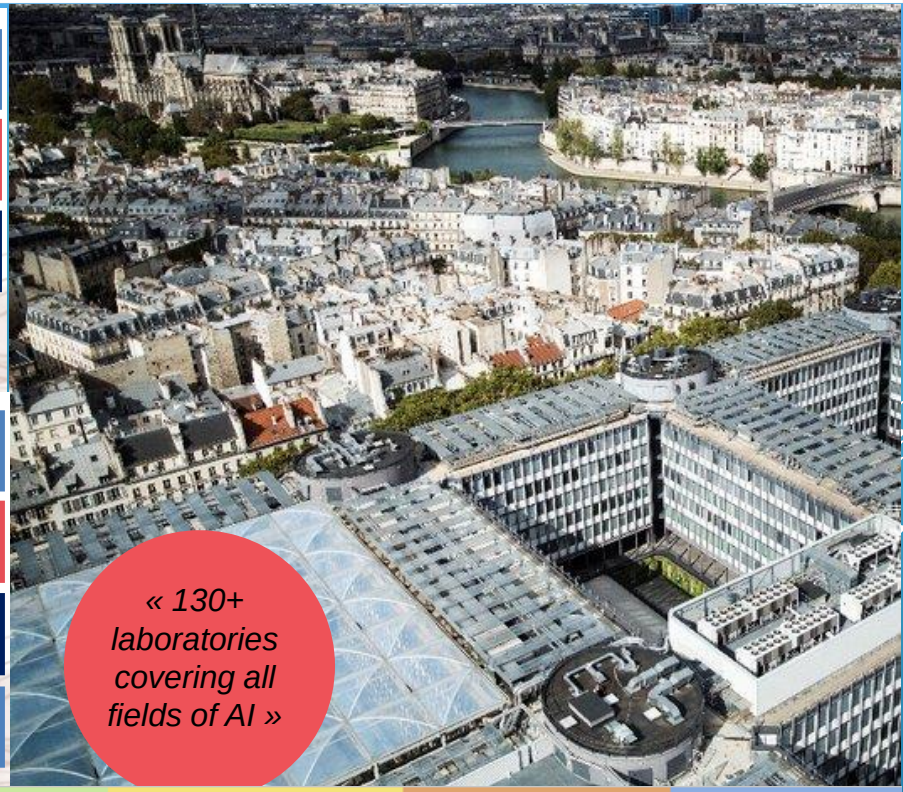
10	Scientists	20	Industrial partners
150	Doctoral and postdoctoral researchers	8	Academic partners
30	Master's students trained each year	5	Master's degrees + lifelong learning programs
2	Locations in Paris and Abu Dhabi		
1	Chairs of excellence	5	Funding opportunities
2	Interdisciplinary projects	6	Doctoral program
3	Collaborative responses to scientific calls	7	Scientific events
4	Industrial partnerships	8	Innovative training programs



« 130+ laboratories covering all fields of AI »

ellis unit | PARIS

SEPTEMBER 15TH 2020

GSI'21 Figures

- ***GSI'21 Registrations:*** *180 participants (2/3 In person)*
- ***GSI'21 Program***
  - *6 Keynote Speakers*
  - *101 talks in 22 Oral sessions*
  - *13 Posters in 2 Poster sessions*
- ***Papers Acceptance Rate of 83% based on 389 reviews (minimum of 2 reviews per paper)***
- ***Papers Origin:*** *France 36%, Germany 11%, USA 10%, Japan 10% , UK 4%, Denmark 3%, Netherlands 3%, Russia 2%, Poland 2%*
- ***But also from:*** *Australia, Austria, Belgium , Canada, Chile, China , Croatia, Czechia, India, Mexico, Nigeria, Norway, Portugal, Romania, Spain, Sweden, Switzerland, United Arab Emirates Venezuela, Viet Nam*

22 GSI'21 Oral Sessions

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- **Probability & statistics on Riemannian Manifolds** - Chairs: **Xavier Pennec, Cyrus Mostajeran**
- **Shapes Spaces** - Chairs: **Salem Said, Joan Glaunès**
- **Geometric and structure preserving discretizations** - Chairs: **Alessandro Bravetti, Manuel de Leon**
- **Lie Group Machine Learning** - Chairs: **Frédéric Barbaresco, Gery de Saxcé**
- **Harmonic Analysis on Lie Groups** - Chairs: **Jean-Pierre Gazeau, Frédéric Barbaresco**
- **Geometric Mechanics** - Chairs: **Gery de Saxcé, Frédéric Barbaresco**
- **Sub-Riemannian Geometry and Neuromathematics** - Chairs: **Alessandro Sarti, Dario Prandi**
- **Statistical Manifold & Hessian Information Geometry** - Chairs: **Noemie Combe, Michel Nguiffo Boyom**
- **Information Geometry in Physics** - Chairs: **Geert Verdoolaege, Jun Zhang**
- **Geometric & Symplectic Methods for Hydrodynamical Models** - Chairs: **Cesare Tronci, François Gay-Balmaz**
- **Geometry of Quantum States** - Chairs: **Florio Maria Ciaglia, Michel Berthier**
- **Deformed entropy, cross-entropy, and relative entropy** - Chairs: **Ting-Kam Leonard Wong, Léonard Monsaingeon**
- **Geometric structures in thermodynamics and statistical physics** - Chairs: **Hiroaki Yoshimura, François Gay-Balmaz**
- **Geometric Deep Learning** - Chairs: **Gabriel Peyré, Erik J. Bekkers**
- **Computational Information Geometry 1** - Chairs: **Frank Nielsen, Clément Gauchy**
- **Computational Information Geometry 2** - Chairs: **Giovanni Pistone, Goffredo Chirco**
- **Optimal Transport & Learning** - Chairs: **Yaël Frégier, Nicolas Garcia Trillos**
- **Statistics, Information and Topology** - Chairs: **Pierre Baudot, Michel Nguiffo Boyom**
- **Topological and Geometrical Structures in Neurosciences** - Chairs: **Pierre Baudot, Giovani Petri**
- **Manifolds & Optimization** - Chairs: **Stéphanie Jehan-Besson, Bin Gao**
- **Divergence Statistics** - Chairs: **Michel Broniatowski, Wolfgang Stummer**
- **Transport information geometry** - Chairs: **Wuchen Li, Philippe Jacquet**

GSI'21 keynote speakers

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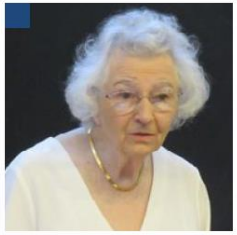
Michel Broniatowski

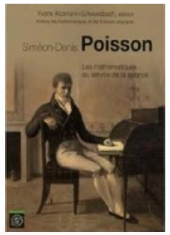
TITLE: SOME INSIGHTS ON STATISTICAL DIVERGENCES AND CHOICE OF MODELS

Maurice de Gosson

TITLE: GAUSSIAN STATES FROM A SYMPLECTIC GEOMETRY POINT OF VIEW

Yvette Kosmann-Schwarzbach





TITLE: STRUCTURES OF POISSON GEOMETRY: OLD AND NEW

Giuseppe Longo

TITLE: USE AND ABUSE OF «DIGITAL INFORMATION» IN LIFE SCIENCES, IS GEOMETRY OF INFORMATION A WAY OUT?

Jean Petitot

TITLE : THE PRIMARY VISUAL CORTEX AS A CARTAN ENGINE

Max Welling

TITLE: EXPLORING QUANTUM STATISTICS FOR MACHINE LEARNING

GSI'21 OPENING DAY, July 21st
Amphi RICHELIEU – Sorbonne Université

08.30–09.00	Welcome Desk	
09.00–09.30	**Opening by GSI'21 chairs & sponsors** Frédéric BARBARESCO & Frank NIELSEN	
09.30–10.30	**Use and abuse of «digital information» in life sciences, is Geometry of Information a way out?** Giuseppe LONGO - Centre Cavaillès, CNRS & Ens Paris and School of Medicine, Tufts University, Boston	Keynote chair: Frédéric BARBARESCO
10.30–11.00	**Coffee Break + Group Photo**	
11.00–12.00	**Structures of Poisson geometry: old and new** Yvette KOSMANN-SCHWARZBACH - Professeur des universités honoraire - France	Keynote chair: Gery de SAXCE
12.00–14.00	**Lunch Break** (*not included*) + mini-hackathon GEOMSTATS at SCAI	Mini-hackathon: Nina Miolane
14.00–15.00	**Some insights on statistical divergences and choice of models** Michel BRONIATOWSKI - Sorbonne Universté, France	Keynote Chair: Frank NIELSEN
15.00–16.00	**Gaussian states from a symplectic geometry point of view** Maurice de GOSSON - Faculty of Mathematics, NuHAG group - University of Vienna, Austria	Keynote Chair: Jean-Pierre GAZEAU
16.00–16.30	**Coffee Break**	
16.30–17.30	**Exploring quantum statistics for machine learning** Max WELLING, Informatics Institute, University of Amsterdam and Qualcomm Technologies	Keynote Chair: Gabriel PEYRE
17.30–18.30	**The primary visual cortex as a Cartan engine** Jean PETITOT - CAMS, EHESS (Ecole des Hautes Etudes en Sciences Sociales)	Keynote Chair: Daniel BENNEQUIN
20.00–21.30	**Welcome cocktail** - SCAI Sorbonne (Jussieu site)	

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PLENARY SESSION JULY 21ST

Amphithéâtre Richelieu
Paris-Sorbonne University
17 rue de la Sorbonne, 75005 Paris

GSI'21, July 22nd
Jussieu site - Sorbonne Université

	SESSIONS ROOM A	SESSIONS ROOM B
08.30-10.10	**Probability & statistics on Riemannian Manifolds** Chairs: Xavier Pennec, Cyrus Mostajeran	**Sub-Riemannian Geometry and Neuromathematics** Chairs: Alessandro Sarti, Dario Prandi
10.10-10.30	**Coffee Break + Posters Session 1**	
10.30-12.10	**Shapes Spaces** Chairs: Salem Said, Joan Glaunès	**Geometry of Quantum States** Chairs: Florio Maria Ciaglia, Michel Berthier
12.10-13.10	**Lunch Break** *(not included)* + mini-hackathon GEOMSTATS at SCAI	
13.10-14.30	**Geometric and structure preserving discretizations** Chairs: Alessandro Bravetti, Manuel de Leon	**Information Geometry in Physics** Chairs: Geert Verdoolaege, Jun Zhang
14.30-16.10	**Lie Group Machine Learning** Chairs: Frédéric Barbaresco, Gery de Saxcé	**Geometric & Symplectic Methods for Hydrodynamical Models** Chairs: Cesare Tronci, François Gay-Balmaz
16.10-16.30	**Coffee Break + Posters Session 1**	
16.30-18.10	**Harmonic Analysis on Lie Groups** Chairs: Jean-Pierre Gazeau, Frédéric Barbaresco	**Statistical Manifold & Hessian Information Geometry** Chairs: Noemie Combe, Michel Nguiffo Boyom
18.10-19.30	**Geometric Mechanics** Chairs: Gery de Saxcé, Frédéric Barbaresco	**Deformed entropy, cross-entropy, and relative entropy** Chairs: Ting-Kam Leonard Wong, Léonard Monsaingeon
20.00-22.30	**GALA Dinner**	

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SESSIONS JULY 22ND

Centre International de Conférences
Sorbonne Université
Patio 44, 4 place Jussieu 55,
75005 Paris

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GSI'21, July 23rd Jussieu site – Sorbonne Université		
	SESSIONS ROOM A	SESSIONS ROOM B
08.30–09.50	**Transport information geometry** Chairs: Wuchen Li, Philippe Jacquet	**Statistics, Information and Topology** Chairs: Pierre Baudot, Michel Nguiffo Boyom
09.50–10.10	**Coffee Break + Posters Session 2**	
10.10–11.50	**Geometric Deep Learning** Chairs: Gabriel Peyré, Erick J. Bekkers	**Topological and Geometrical Structures in Neurosciences** Chairs: Pierre Baudot, Giovani Petri
11.50–13.00	**Lunch Break** *(not included)* + mini-hackathon GEOMSTATS at SCAI	
13.00–14.40	**Computational Information Geometry 1** Chairs: Frank Nielsen, Clément Gauchy	**Manifolds & Optimization** Chairs: Stéphanie Jehan-Besson, Bin Gao
14.40–16.20	**Computational Information Geometry 2** Chairs: Giovanni Pistone, Goffredo Chirco	**Divergence Statistics** Chairs: Michel Broniatowski, Wolfgang Stummer
16.20–16.40	**Coffee Break + Posters Session 2**	
16.40–18.00	**Optimal Transport & Learning** Chairs: Yaël Frégier, Nicolas Garcia Trillos	**Geometric structures in thermodynamics and statistical physics** Chairs: Hiroaki Yoshimura, François Gay-Balmaz
18.00–18.30	**GSI'21 Closure**	

SESSIONS JULY 23RD

Centre International
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Sorbonne Université
Patio 44, 4 place Jussieu 55,
75005 Paris

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Poster Sessions

Poster Session 1	
Clustering Schemes on the Torus with Application to RNA Clashes	Henrik Wiechers, Benjamin Eltzner, Stephan F. Huckemann and Kanti V. Mardi
Separating Point Patterns for Fingerprints	Johannes Wieditz, Yvo Pokern, Dominic Schuhmacher, and Stephan Huckemann
Statistical manifolds & Hidden symmetries	Noemie Combe, Philippe Combe, and Hanna Nencka
Nonparametric Estimation of Probability Density Functions with Gaussian Processe	T. T. Tran, C. Samir, and A. Fradi
On Information (pseudo) Metric	Pierre Baudot
Nonparametric Regression on the Compact Stiefel Manifold	Ines Adouani and Chafik Samir
On Riemannian Stochastic Approximation Schemes with Fixed Step-Size	Alain Durmus, Pablo Jiménez, Éric Moulines, Salem Said

Poster Session 2	
Application of information geometry in uncertainty quantification of computer codes	Clément Gauchy and Jérôme Stenger
On Geometry of Stein Goodness-of-fit Testing	Wenkai Xu and Takeru Matsuda
Simulation of Quantum Noise for Coherent States	Marco Frasca and Alfonso Farina
On the Quantization of the Uniform Source on the n–Sphere (n = 1,2,3)	Stéphane Ragot and Mohamed Yaoumi
Flattening Multiparameter Hierarchical Clustering Functors	Dan Shiebler
Learning the GENERIC evolution	Martin Sípkă and Michal Pavelka

Computational Geometric Science of Information: GEOMSTATS HACKATHON

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Nina Miolane

If you are interested in:

✔ using and understanding existing implementations of differential geometry,
✔ implementing ideas, examples, experiments for a/your research paper,
✔ adding hands-on exercises or examples to your differential geometry classes,
✔ learning how to code differential geometric structures,
✔ learning how to contribute to an open-source GitHub project,

Come to the hackathon!

When?
21st, 22nd & 23rd of July from 12.30 pm to 2.30 pm (lunch break)

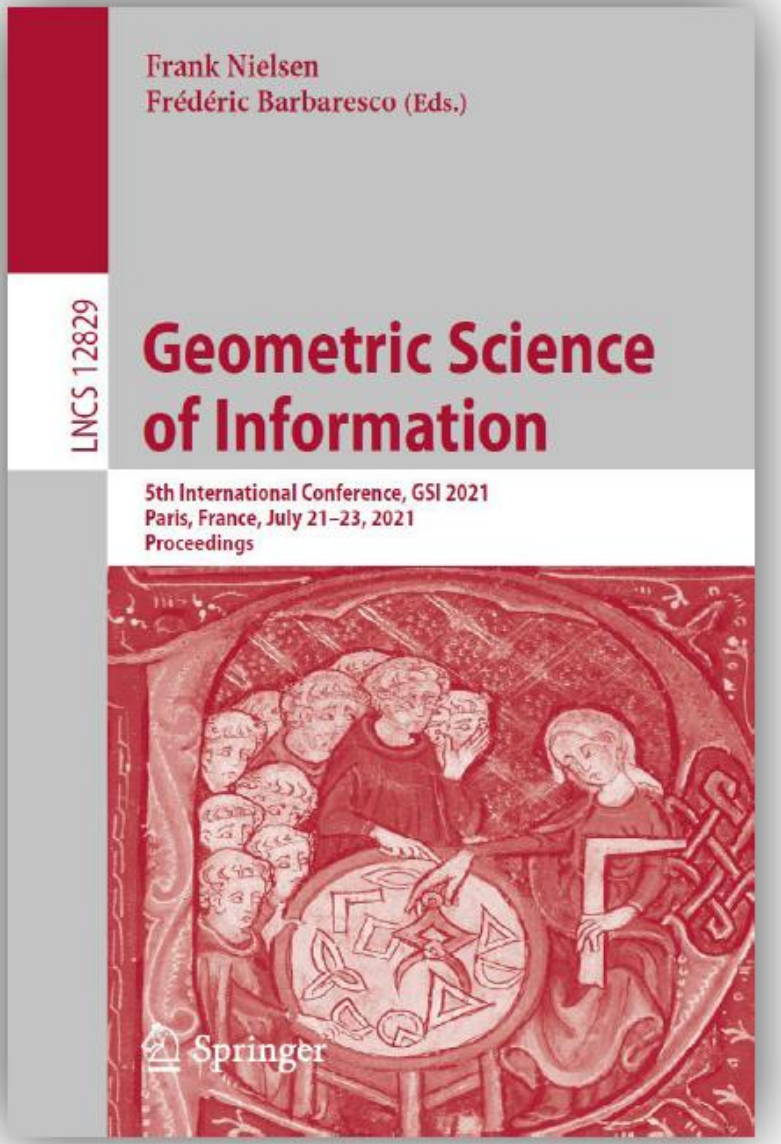
Where?
Esclangon building at SCAI, 2nd floor / (see map 44)

How?
Metro: Jussieu (lines 7 and 10)

Nicolas Guigui

Nicolas Guigui and **Nina Miolane** will be available to answer your questions about computational geometric science of information, guide you through existing implementations, and help you translate your ideas into code. Feel free to join any day, for any duration, with or without a computational project in mind, with or without coding experience!

| GSI'21 Proceedings



https://www.springer.com/gp/book/9783030802080

https://franknielsen.github.io/GSI/

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GSI'21 Papers Awards

The 5th international conference on
Geometric Science of Information
Learning geometric structures

Best Paper Award

GSI 2021
July 21st-23rd 2021
Paris-Sorbonne University

PRESENTED TO
First1 Last1 and First2 Last2.....
AUTHOR(S) OF THE PAPER
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Frank Nielsen
Sony Computer Science Laboratories, Japan
General co-chair

Gabriel Peyré
CNRS, ENS, France
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Lecture Notes in Computer Science
LNCS LNAI LNBI

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mathematics

The 5th international conference on
Geometric Science of Information
Learning geometric structures

WiMLDS Best Paper Award

GSI 2021
July 21st-23rd 2021
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Organization

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Frédéric Barbaresco, President of SEE ISIC Club, THALES KTD PCC SENSING SEGMENT LEADER, Meudon, France

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Xavier Fresquet, Sorbonne Center for AI (SCAI) Deputy Director
Michel Broniatowski, Sorbonne University Professor (LPSM lab)
Jean-Pierre Françoise, Sorbonne University Professor (JLL lab)
Olivier Schwander, Sorbonne University Professor (LIP6 lab)
Gabriel Peyré, ELLIS Paris Unit & ENS Paris

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Rodolphe Sepulchre, Cambridge University
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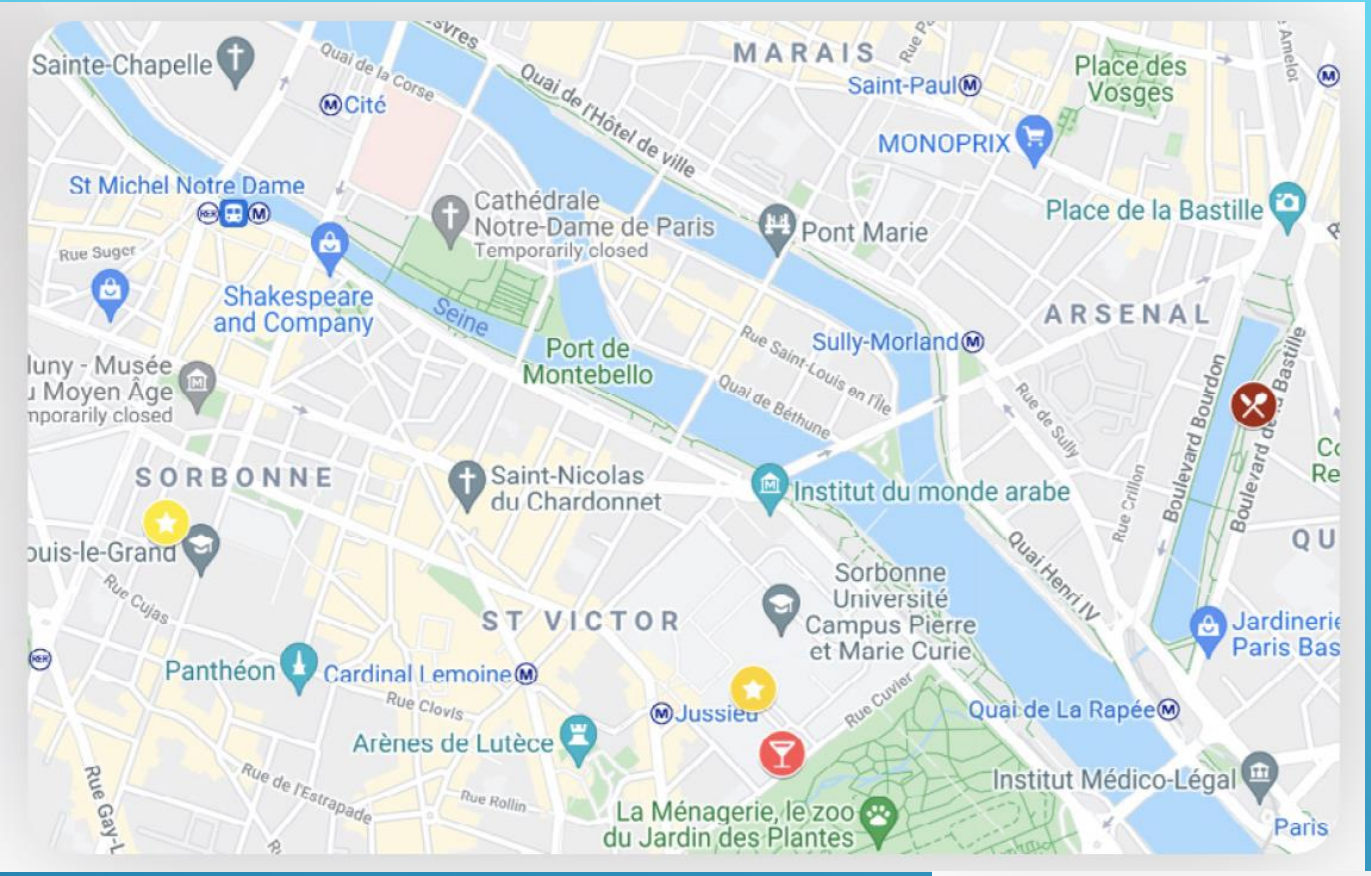
Wolfgang Stummer, University of Erlangen-Nürnberg
Zdravko Terze, University of Zagreb
Geert Verdoolaege, Ghent University
Wuchen Li, UCLA
Hiroaki Yoshimura, Waseda University
Jean Claude Zambrini, Universidade de Lisboa
Jun Zhang, University of Michigan



| Event Map for GSI'21

Sessions Locations

July 21st
Amphithéâtre Richelieu
Paris-Sorbonne University
17 rue de la Sorbonne, 75005 Paris

July 22nd & 23rd
Centre International
de Conférences
Sorbonne Université
Patio 44, 4 place Jussieu 55,
75005 Paris

Welcome Cocktail

July 21st
SCAI
Sorbonne Université
Campus Pierre et Marie Curie 4
Place Jussieu, 75005 Paris

Gala Dinner Boat Cruise

July 22nd
Boarding Point Canauxrama
Port de l'Arsenal
Port on Canal Saint-Martin facing
50 bd de la Bastille, 75012 Paris

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Comment venir à scai ?
Longer l'allée à droite de l'entrée principale jusqu'au dernier bâtiment « Esclangon ».
A l'intérieur du bâtiment Esclangon, prenez la 1ère sortie à gauche puis l'escalier à droite. scai se situe en haut des marches.

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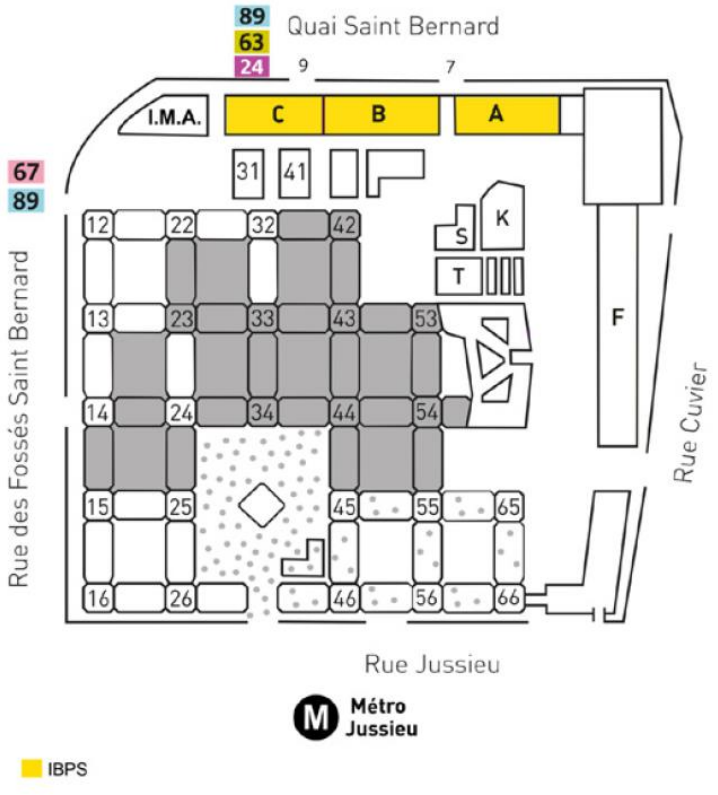
Location Information



Welcome Cocktail

July 21st

SCAI
Sorbonne Université
Campus Pierre et Marie Curie 4
Place Jussieu, 75005 Paris

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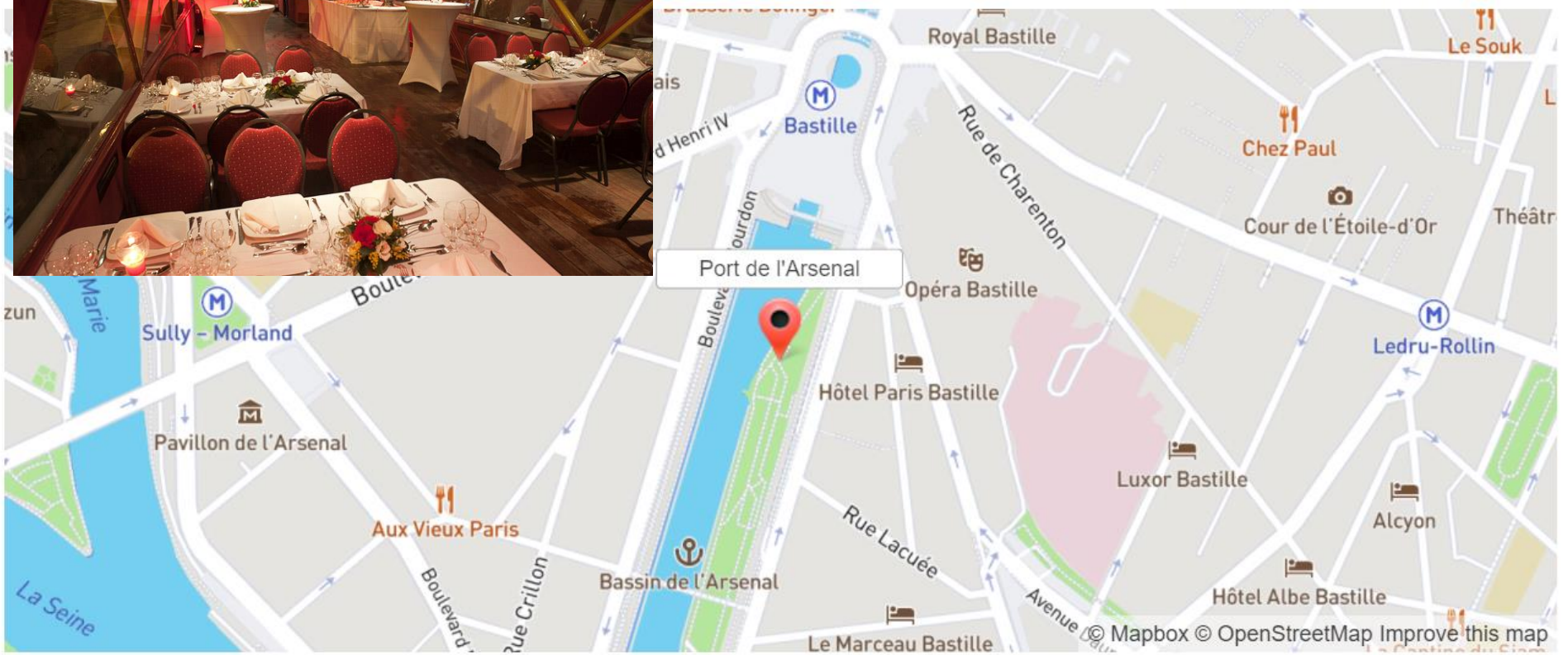
SCAI@Paris

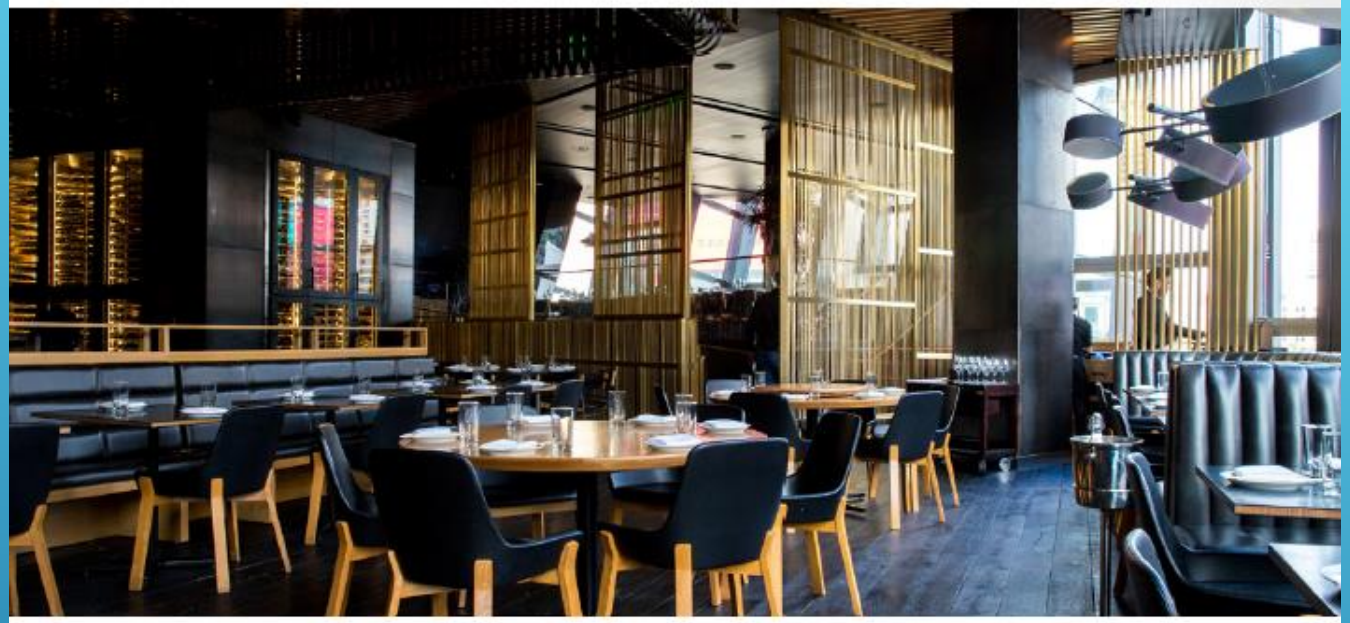
Gala Dinner Boat Cruise

July 22nd

Boarding Point Canauxrama
Port de l'Arsenal
Port on Canal Saint-Martin facing
50 bd de la Bastille, 75012 Paris



List of restaurants



Looking for a restaurant nearby La Sorbonne or Jussieu site?

The area is full of nice restaurants with French, Italian, American, Chinese specialities.

Scan the QR code below to get the list:

| WiFi Access

July 21st
Sorbonne site

ID: **GSI_21**

Password: **6ks896si**

July 22nd & 23rd
Jussieu site

A personal code for each attendee will be available at the Registration Desk.

Feel free to ask for one!

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Welcome message from Frank Nielsen

Sony Computer Science Laboratories Inc.
GSI 2021 co-chair

Sony CSL

GSI biannual conferences

https://franknielsen.github.io/GSI/

GSI'13 Mines ParisTech

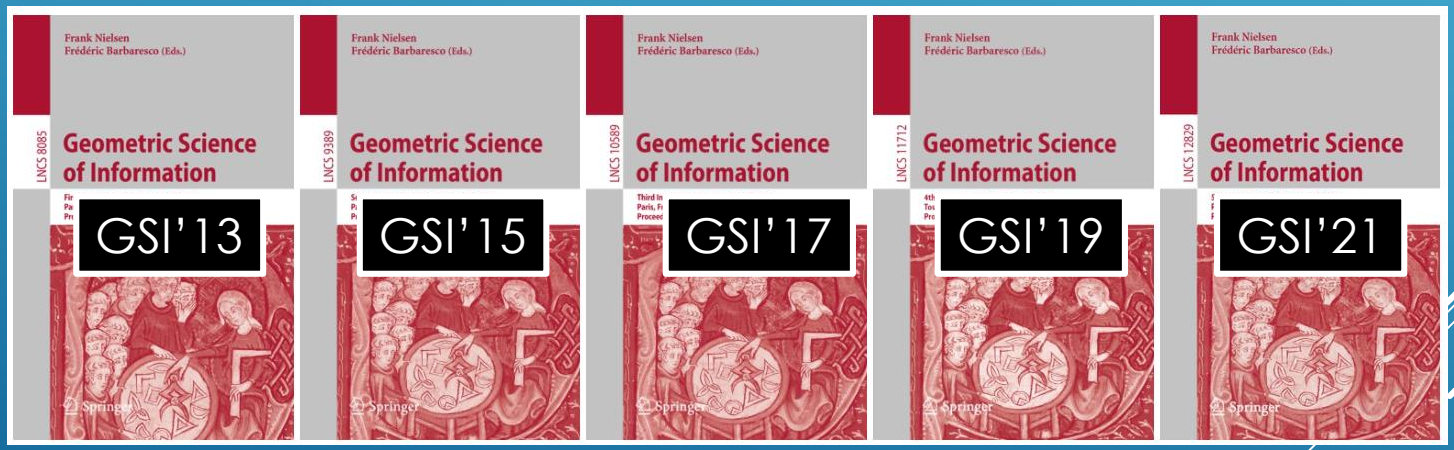
GSI'15 Ecole Polytechnique

GSI'17 Mines ParisTech

GSI'19 ENAC

GSI LNCS Proceedings

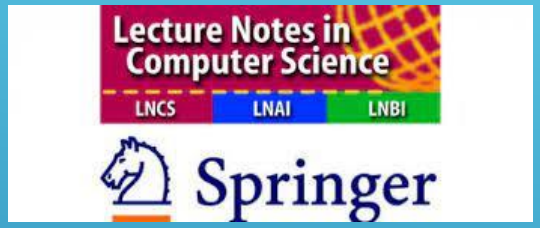
About 500 papers in
about 4500 pages



https://link.springer.com/conference/gsi

GSI 2021: Two awards with prizes

- "**GSI21 Best paper**" sponsored by Springer (1000€)



- "**WiMLDS GSI21 Best paper**" sponsored by MDPI Mathematics (1000€)

https://franknielsen.github.io/GSI/

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TGSI'17 CIRM

FGSI'19 IMAG

GRETSI'19 PEYRESQ

SPIGL'20 LES HOUCHES

Last Publications

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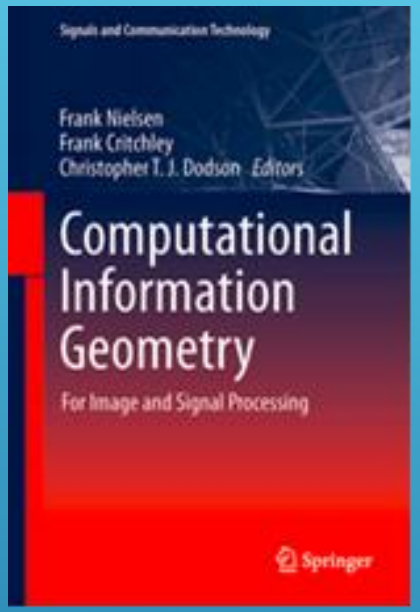
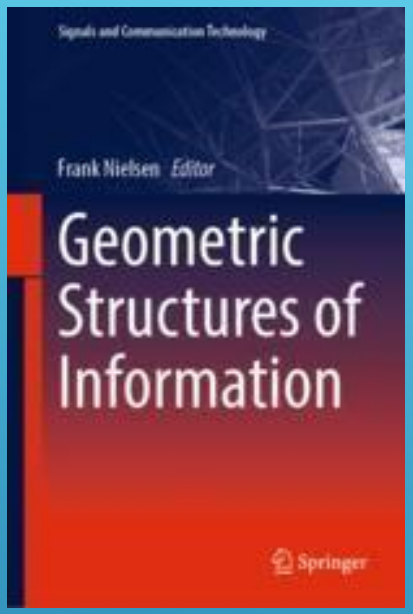
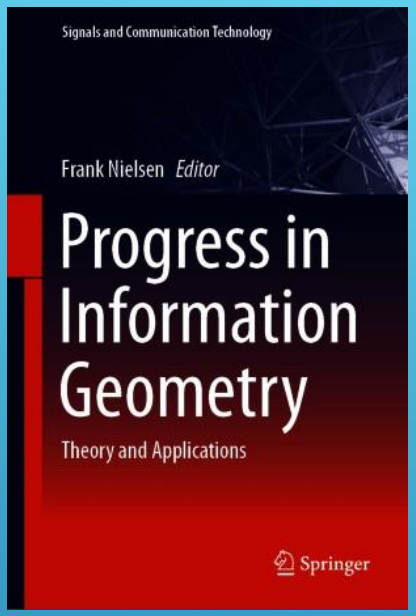
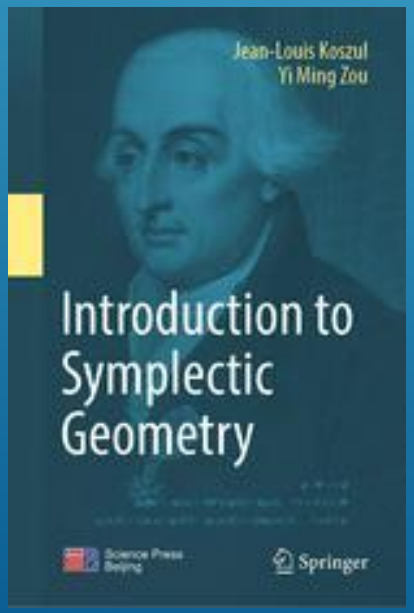
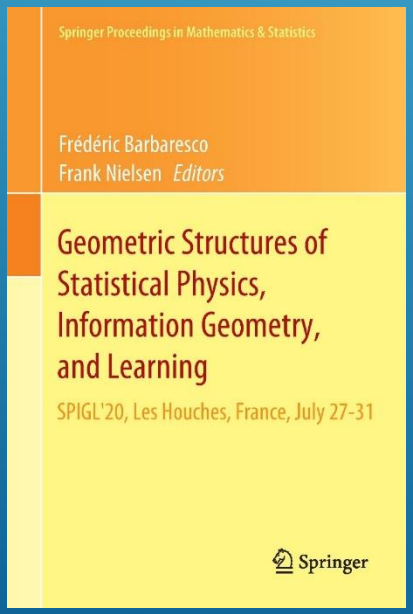
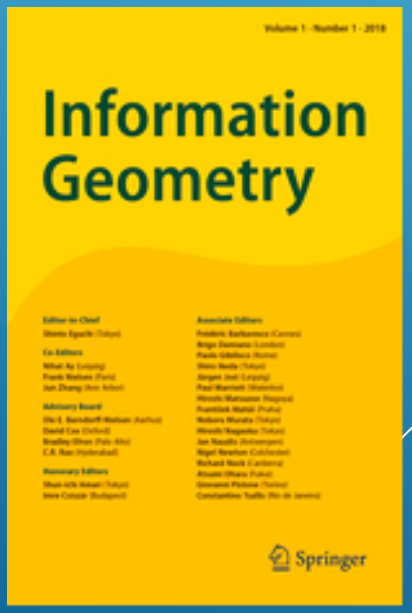












Jean-Louis Koszul · Yiming Zou

Introduction to Symplectic Geometry

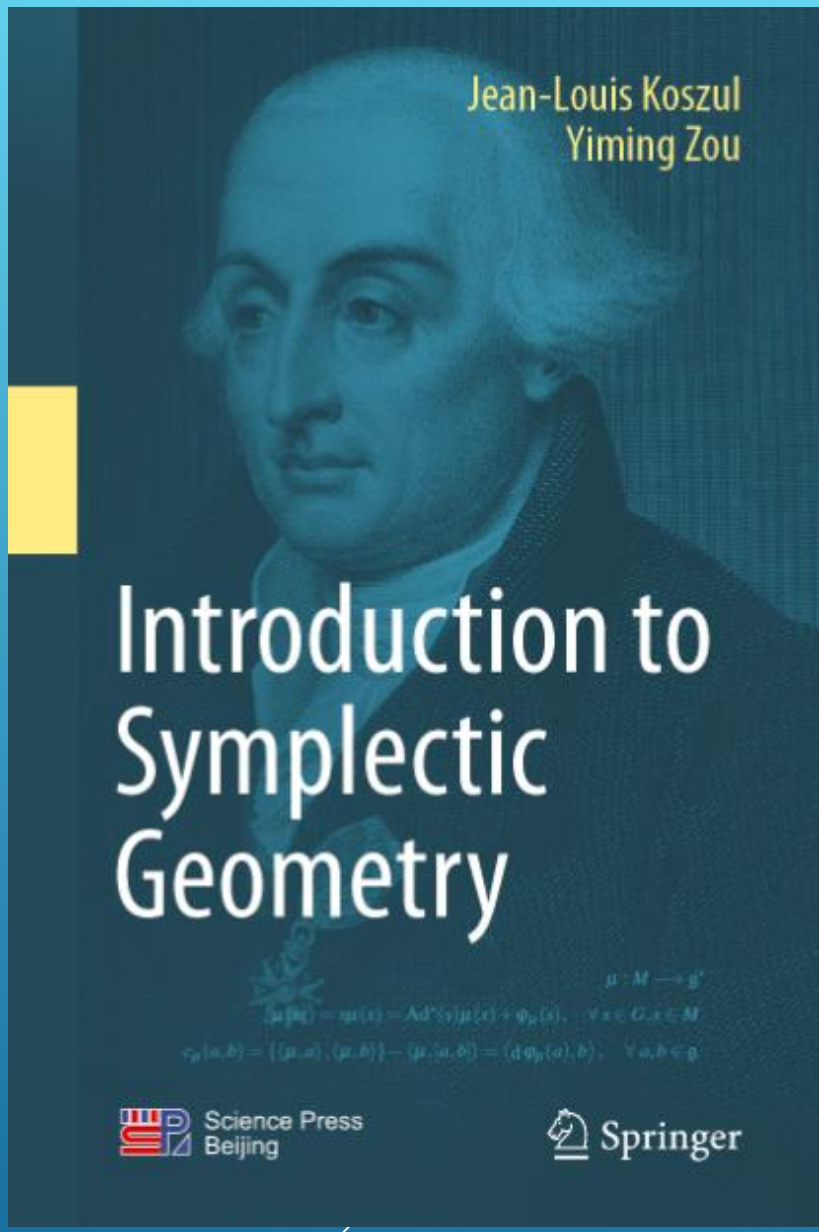
Forewords by Michel Nguiffo Boyom, Frédéric Barbaresco and Charles-Michel Marle

This introductory book offers a unique and unified overview of symplectic geometry, highlighting the differential properties of symplectic manifolds. It consists of six chapters: Some Algebra Basics, Symplectic Manifolds, Cotangent Bundles, Symplectic G-spaces, Poisson Manifolds, and A Graded Case, concluding with a discussion of the differential properties of graded symplectic manifolds of dimensions (o,n). It is a useful reference resource for students and researchers interested in geometry, group theory, analysis and differential equations.

$$\mu : M \longrightarrow \mathfrak{g}^*$$

$$\mu(sx) = s\mu(x) = \mathrm{Ad}^*(s)\mu(x) + \varphi_\mu(s), \quad \forall\, s \in G, x \in M$$

$$c_\mu(a,b) = \{\langle \mu, a\rangle, \langle \mu, b\rangle\} - \langle \mu, [a,b]\rangle = \langle \mathrm{d}\varphi_\mu(a), b\rangle, \quad \forall\, a,b \in \mathfrak{g}$$



ECOLE DE PHYSIQUE DES HOUCHES SPIGL'20, JULY 2020

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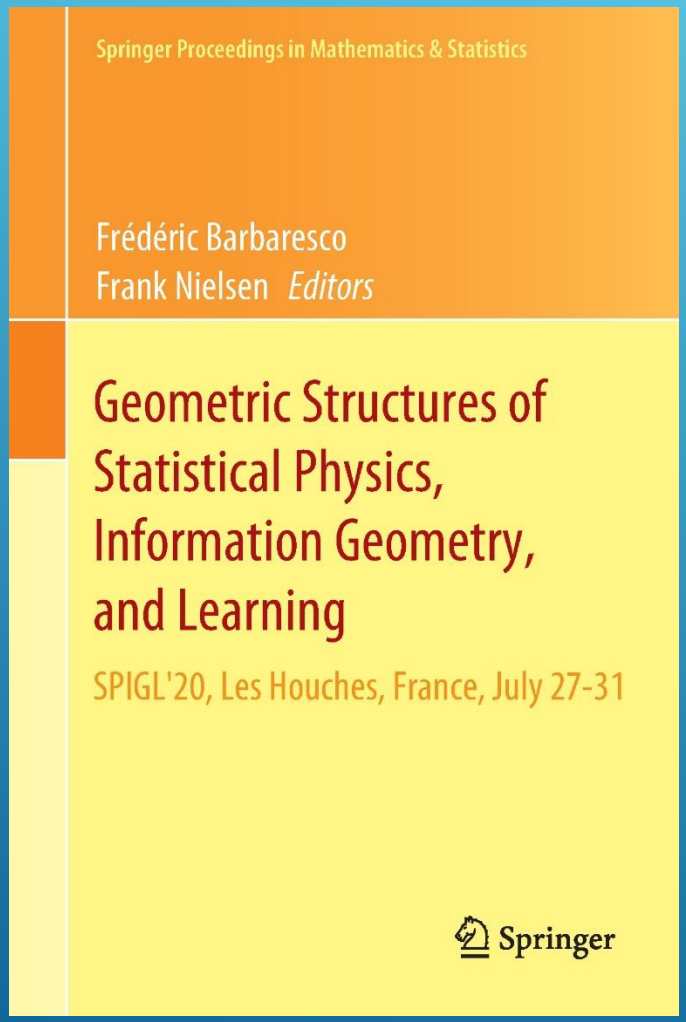
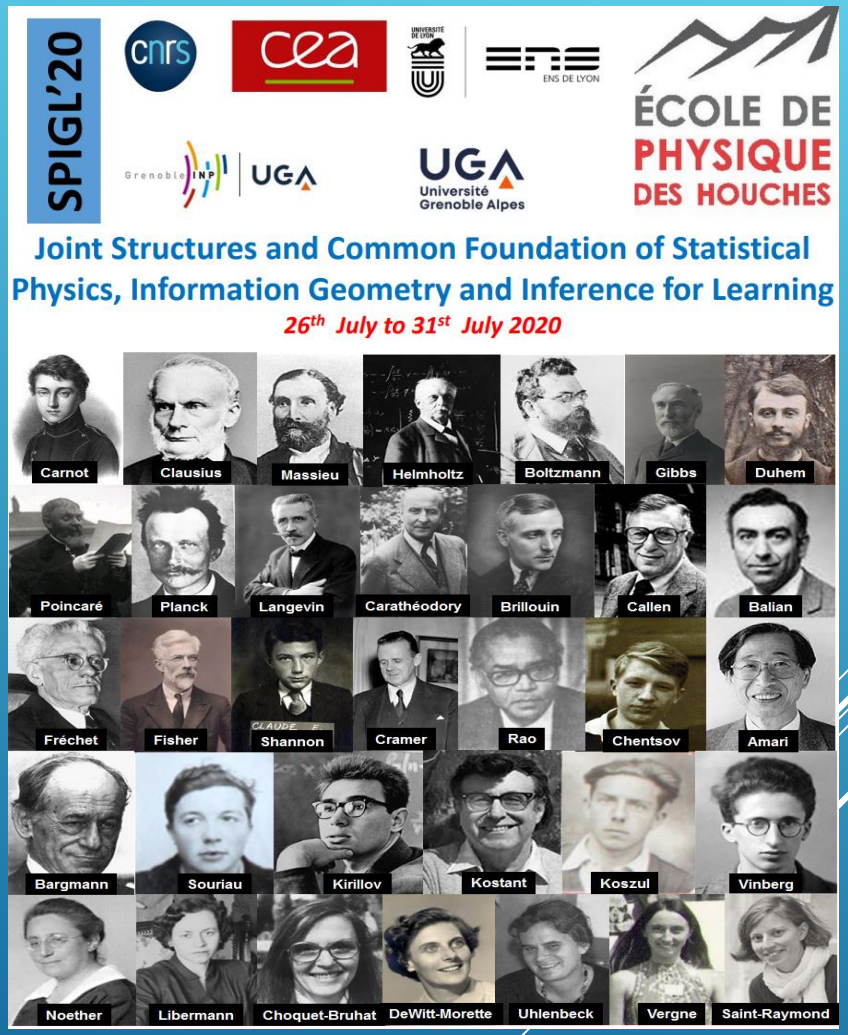




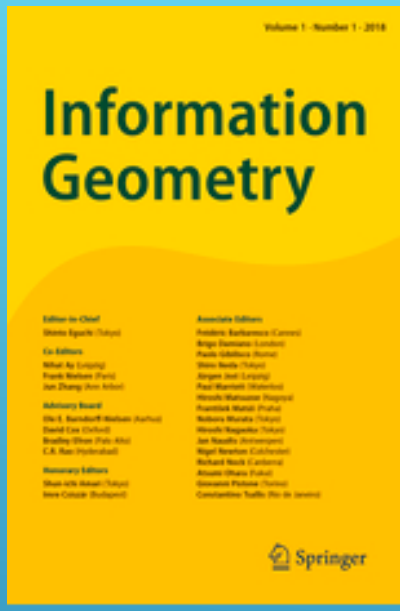
https://www.springer.com/jp/book/9783030779566

https://www.youtube.com/playlist?list=PLo9ufcrEqwWExTBPgQPJwAJhoUChMbR

Or

https://franknielsen.github.io/SPIG-LesHouches2020/

SPRINGER « INFORMATION GEOMETRY » Journal
Volume 4, Issue 1, July 2021
https://link.springer.com/journal/41884/volumes-and-issues/4-1



Information Geometry (2021) 4:155–157
https://doi.org/10.1007/s41884-020-00042-2

PREFACE

Check for updates

Special Issue "Affine differential geometry and Hesse geometry: a tribute and memorial to Jean–Louis Koszul"

Hideyuki Ishi[1]

Published online: 7 January 2021
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https://link.springer.com/article/10.1007/s41884-020-00042-2

International Conference on Bayesian and Maximum Entropy methods in Science and Engineering, MaxEnt 2022

July 18-22 2022, Institut Henri Poincaré, Paris

Local organizers:

- Ali Mohammad-Djafari
- Frédéric Barbaresco
- Frank Nielsen
- Martino Trassinelli
- Lune Maillard
- Leila Gharsali
- Maria Trocan
- …

MaxEnt'14 Clos Lucé

Scientific committee:

- John Skilling
- Kevin Knuth
- Udo von Toussaint
- Ariel Caticha
- Robert Niven
- Wolfgang von der Linden
- Julio Michael Stern
- Romke Bontekoe
- Barrie Stokes
- Donald Nelson
- Keith Earle
- …

Institutions & Locals

Institut Henri Poincaré
http://www.ihp.fr/en
Institut des NanoSciences de Paris (INSP)
http://www.insp.upmc.fr
Institut des Neurosciences Paris-Saclay
https://neuropsi.cnrs.fr/
Sorbonne Center for Artificial Intellegence (SCAI)
https://scai.sorbonne-universite.fr/
Institut DATAIA
https://dataia.eu/en
Artificial Intelligence in Paris and Europe
https://ellis-paris.github.io/
SEE: Société de l'électricité, de l'électronique et des technologies de l'information et de la communication
https://www.see.asso.fr/
ISCT: https://isct7.webnode.com/

THE SEVEN LIBERAL ARTS: GEOMETRIA

Liberal arts, college or university curriculum aimed at imparting general knowledge and developing **general intellectual capacities in contrast to a professional, vocational, or technical curriculum**. In the medieval European university the seven liberal arts were **grammar**, **rhetoric**, and **logic** (**the trivium**) and **geometry**, **arithmetic**, **music**, and **astronomy** (**the quadrivium**).

IMAGES OF THE SEVEN LIBERAL ARTS

BLAISE PASCAL
ALEA GEOMETRIA

- In 1654, Blaise Pascal submitted a paper to « *Celeberrimae matheseos Academiae Parisiensi* » entitled « ***ALEAE GEOMETRIA : De compositione aleae in ludis ipsi subjectis*** »
  - « … *et sic matheseos demonstrationes cum aleae incertitudine jugendo, et quae contraria videntur conciliando, ab utraque nominationem suam accipiens, stupendum hunc titulum jure sibi arrogat:* ***Aleae Geometria*** »
  - « … *par l'union ainsi réalisée entre les démonstrations des mathématiques et l'incertitude du hasard, et par la conciliation entre les contraires apparents, elle peut tirer son nom de part et d'autre et s'arroger à bon droit ce titre étonnant:* ***Géométrie du Hasard*** »
  - « … *by the union thus achieved between the demonstrations of mathematics and the uncertainty of chance, and by the conciliation between apparent opposites, it can take its name from both sides and arrogate to right this amazing title:* ***Geometry of Chance*** »

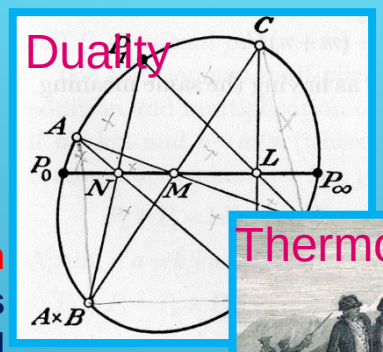
Saint-Étienne-du-Mont Church
(7 minutes walk from Sorbonne)

Blaise Pascal and DUALITY

Pascal's **Hexagrammum Mysticum Theorem**, and its **dual Brianchon's Theorem**. In 1639 Blaise Pascal discovered, at age sixteen, the famous hexagon theorem, also developed in “Essay pour les Coniques”, printed in 1640, declaring his intention of writing a treatise on conics in which he would derive the major theorems of Apollonius from his new theorem.

Blaise Pascal and COMPUTER

Pascaline marks the beginning of the development of mechanical calculus in Europe, followed by Charles Babbage analytical machine from 1834 to 1837, a programmable calculating machine combining the inventions of Blaise Pascal and Jacquard’s machine, with instructions written on perforated cards.



Blaise Pascal and THERMODYNAMICS

Pascal's Experiment in the Puy de Dôme to Test the **Relation between Atmospheric Pressure and Altitude**. In 1647, Blaise Pascal suggests to raise Torricelli’s mercury barometer at the top of the Puy de Dome Mountain (France) in order to test the "weight of air" assumption

Blaise Pascal and PROBABILITY

The "calculation of probabilities" began in a correspondence between Blaise Pascal and Pierre Fermat. In 1654, Blaise Pascal submitted a short paper to "Celeberrimae matheseos Academiae Parisiensi" with the title **"Aleae Geometria" (Geometry of Chance)**, that was the seminal paper founding Probability as a new discipline in Science.

Painting@La Sorbonne

Desargues, Mersenne, Pascal and Descartes

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FRENCH CONTRIBUTORS TO GEOMETRIC SCIENCE OF INFORMATION

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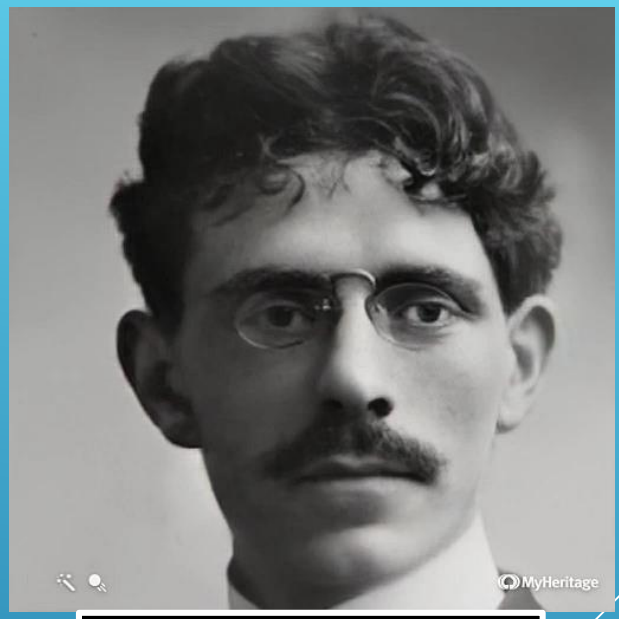
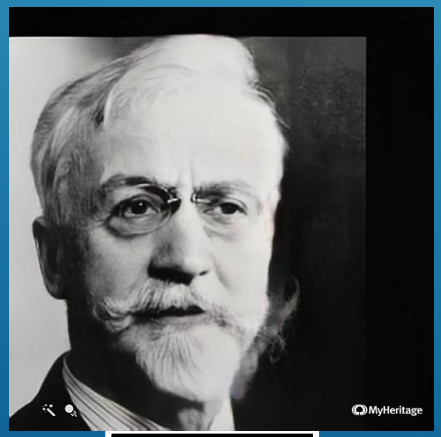
Jean-Marie Souriau (ENS 1942)

Jean-Louis Koszul (ENS 1940)



Maurice Fréchet (ENS 1903)



Elie Cartan

Henri Poincaré

FRENCH CONTRIBUTORS TO CALCULUS OF VARIATIONS

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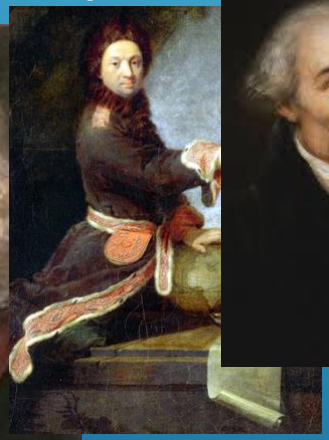
SORBONNE CENTER FOR ARTIFICIAL INTELLIGENCE

Pierre de Fermat

Fermat's principle of least time

Pierre Louis Maupertuis



Maupertuis's principle of least length

Joseph Louis Lagrange

(Euler) Lagrange Equation

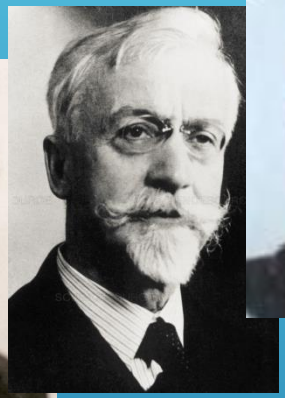
Simeon Denis Poisson

Poisson Bracket, Poisson Geometry Structure

Henri Poincaré

(Euler) Poincaré Equation

Elie Cartan



Poincaré Cartan Integral Invariant

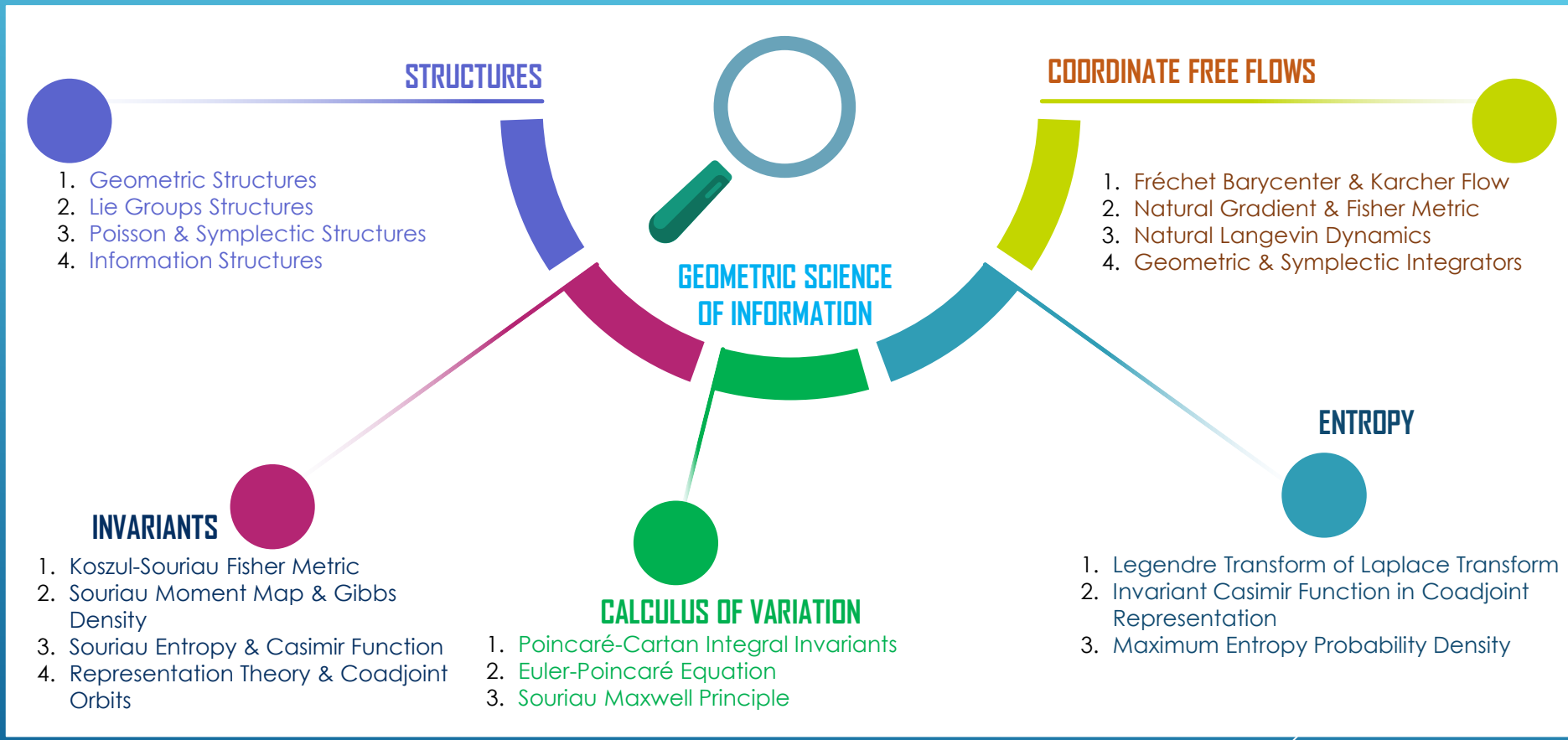
Jean- Marie Souriau

Souriau Moment Map, Souriau Symplectic 2 Form, Lie Groups Thermodynamics

Jean-Michel Bismut

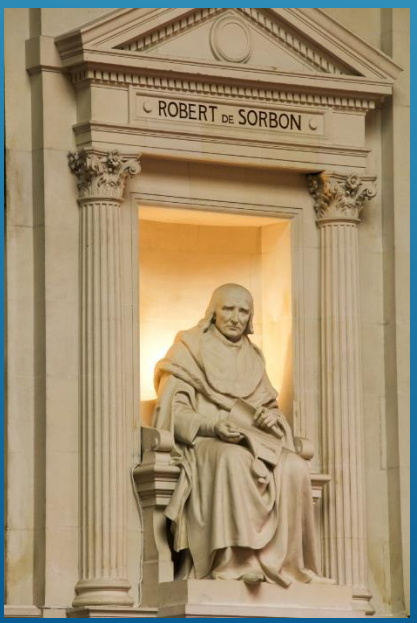
Random Mechanics

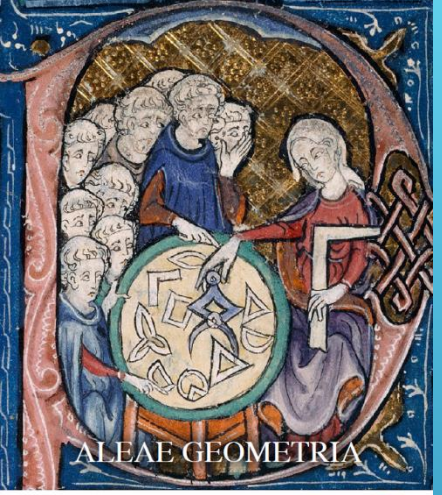
MAIN CONCEPTS BEHIND GEOMETRIC SCIENCE OF INFORMATION



ENJOY GSI'21

« There is nothing more in physical theories than symmetry groups except the mathematical construction which allows precisely to show that there is nothing more » - **Jean-Marie Souriau**





5th GSI'21 Conference

LEARNING GEOMETRIC STRUCTURES

Sorbonne University

July 21st -22nd- 23rd 2021

Giuseppe Longo

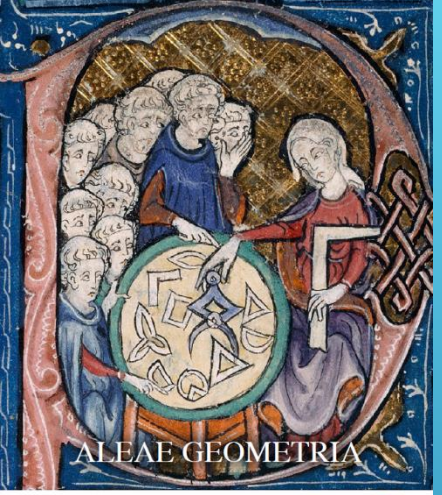
Centre Cavaillès, CNRS & Ens Paris and
School of Medicine, Tufts University, Boston
http://www.di.ens.fr/users/longo/

TITLE: USE AND ABUSE OF «DIGITAL INFORMATION» IN LIFE SCIENCES, IS GEOMETRY OF INFORMATION A WAY OUT?

Abstract:
Since WWII, the war of coding, and the understanding of the structure of the DNA (1953), the latter has been considered as the digital encoding of the Aristotelian Homunculus. Till now DNA is viewed as the «information carrier» of ontogenesis, the main or unique player and pilot of phylogenesis. This heavily affected our understanding of life and reinforced a mechanistic view of organisms and ecosystems, a component of our disruptive attitude towards ecosystemic dynamics. A different insight into DNA as a major constraint to morphogenetic processes brings in a possible «geometry of information» for biology, yet to be invented. One of the challenges is in the need to move from a classical analysis of morphogenesis, in physical terms, to a «heterogenesis» more proper to the historicity of biology.

References

- Arezoo Islami, Giuseppe Longo. ***Marriages of Mathematics and Physics: a challenge for Biology,*** Invited Paper, in The Necessary Western Conjunction to the Eastern Philosophy of Exploring the Nature of Mind and Life (K. Matsuno et al., eds), Special Issue of Progress in Biophysics and Molecula Biology, Vol 131, Pages 179¬192, December 2017. (DOI) (SpaceTimeIslamiLongo.pdf)
- Giuseppe Longo. ***How Future Depends on Past Histories and Rare Events in Systems of Life,*** Foundations of Science, (DOI), 2017 (biolog-observ-history-future.pdf)
- Giuseppe Longo. ***Information and Causality: Mathematical Reflections on Cancer Biology.*** In Organisms. Journal of Biological Sciences, vo. 2, n. 1, 2018. (BiologicalConseq-ofCompute.pdf)
- Giuseppe Longo. ***Information at the Threshold of Interpretation, Science as Human Construction of Sense.*** In Bertolaso, M., Sterpetti, F. (Eds.) A Critical Reflection on Automated Science – Will Science Remain Human? Springer, Dordrecht, 2019 (Information-Interpretation.pdf)
- Giuseppe Longo, Matteo Mossio. ***Geocentrism vs genocentrism: theories without metaphors, metaphors without theories.*** In Interdisciplinary Science Reviews, 45 (3), pp. 380-405, 2020. (Metaphors-geo-genocentrism.pdf)



5th GSI'21 Conference

LEARNING GEOMETRIC STRUCTURES

Sorbonne University

July 21st –22nd– 23rd 2021

Yvette Kosmann-Schwarzbach

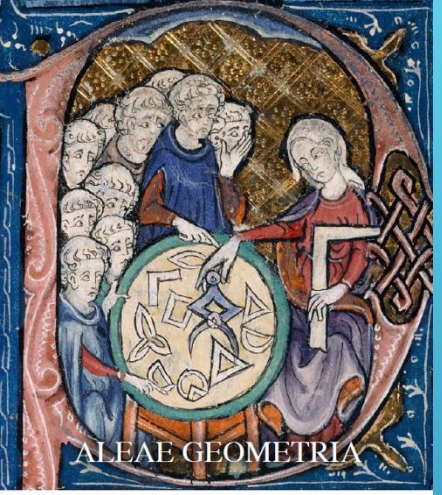
Professeur des universités honoraire

TITLE: STRUCTURES OF POISSON GEOMETRY: OLD AND NEW

Abstract:
How did the brackets that Siméon-Denis Poisson introduce in 1809 evolve into the Poisson geometry of the 1970's? What are Poisson groups and, more generally, Poisson groupoids? In what sense does Dirac geometry generalize Poisson geometry and why is it relevant for applications? I shall sketch the definition of these structures and try to answer these questions.

References:

- P. Libermann and C.-M. Marle, ***Symplectic Geometry and Analytical Mechanics***, D. Reidel Publishing Company (1987).
- J. E. Marsden and T. S. Ratiu, ***Introduction to Mechanics and Symmetry, Texts in Applied Mathematics 17***, second edition, Springer (1998).
- C. Laurent-Gengoux, A. Pichereau, and P. Vanhaecke, ***Poisson Structures, Grundlehren der mathematischen Wissenschaften 347***, Springer (2013).
- Y. Kosmann-Schwarzbach, ***Multiplicativity from Lie groups to generalized geometry, in Geometry of Jets and Fields*** (K. Grabowska et al., eds), Banach Center Publications 110, 2016.
- ***Special volume of LMP on Poisson Geometry***, guest editors, Anton Alekseev, Alberto Cattaneo, Y. Kosmann-Schwarzbach, and Tudor Ratiu, ***Letters in Mathematical Physics 90***, 2009.
- Y. Kosmann-Schwarzbach (éd.), Siméon-Denis Poisson : les ***Mathématiques au service de la science, Editions de l'Ecole Polytechnique*** (2013).
- Y. Kosmann-Schwarzbach, ***The Noether Theorems: Invariance and Conservation Laws in the Twentieth Century***, translated by B. E. Schwarzbach, Sources and Studies in the History of Mathematics and Physical Sciences, Springer (2011).



5th GSI'21 Conference

LEARNING GEOMETRIC STRUCTURES

Sorbonne University

July 21st –22nd– 23rd 2021

Michel Broniatowski

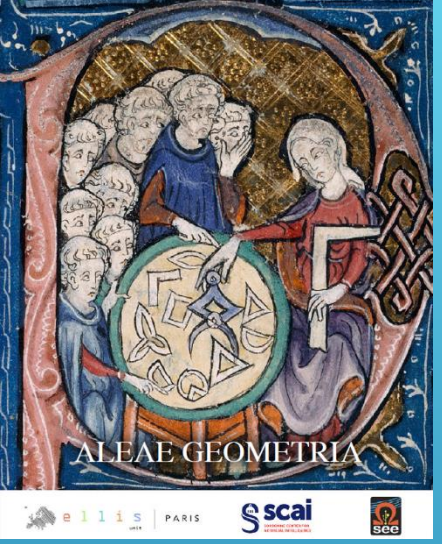
Sorbonne Université, Paris

TITLE: SOME INSIGHTS ON STATISTICAL DIVERGENCES AND CHOICE OF MODELS

Abstract:
Divergences between probability laws or more generally between measures define inferential criteria, or risk functions. Their estimation makes it possible to deal with the questions of model choice and statistical inference, in connection with the regularity of the models considered; depending on the nature of these models (parametric or semi-parametric), the nature of the criteria and their estimation methods vary. Representations of these divergences as large deviation rates for specific empirical measures allow their estimation in nonparametric or semi parametric models, by making use of information theory results (Sanov's theorem and Gibbs principles), by Monte Carlo methods. The question of the choice of divergence is wide open; an approach linking nonparametric Bayesian statistics and MAP estimators provides elements of understanding of the specificities of the various divergences in the Ali-Silvey-Csiszar-Arimoto class in relation to the specific choices of the prior distributions.

References:

- Broniatowski, Michel ; Stummer, Wolfgang. ***Some universal insights on divergences for statistics, machine learning and artificial intelligence.*** In Geometric structures of information; Signals Commun. Technol., Springer, Cham, pp. 149.211, 2019
- Broniatowski, Michel. ***Minimum divergence estimators, Maximum Likelihood and the generalized bootstrap,*** to appear in «Divergence Measures: Mathematical Foundations and Applications in Information-Theoretic and Statistical Problems» Entropy, 2020
- Csiszár, Imre ; Gassiat, Elisabeth. ***MEM pixel correlated solutions for generalized moment and interpolation problems.*** IEEE Trans. Inform. Theory 45, no. 7, 2253–2270, 1999
- Liese, Friedrich; Vajda, Igor. ***On divergences and informations in statistics and information theory.*** IEEE Trans. Inform. Theory 52, no. 10, 4394–4412, 2006



5th GSI'21 Conference

LEARNING GEOMETRIC STRUCTURES

Sorbonne University

July 21st -22nd- 23rd 2021

Maurice de Gosson

Professor, Senior Researcher at the University of Vienna https://homepage.univie.ac.at/maurice.de.gosson
Faculty of Mathematics, NuHAG group

TITLE: GAUSSIAN STATES FROM A SYMPLECTIC GEOMETRY POINT OF VIEW

Abstract:
Gaussian states play an ubiquitous role in quantum information theory and in quantum optics because they are easy to manufacture in the laboratory, and have in addition important extremality properties. Of particular interest are their separability properties. Even if major advances have been made in their study in recent years, the topic is still largely open. In this talk we will discuss separability questions for Gaussian states from a rigorous point of view using symplectic geometry, and present some new results and properties.

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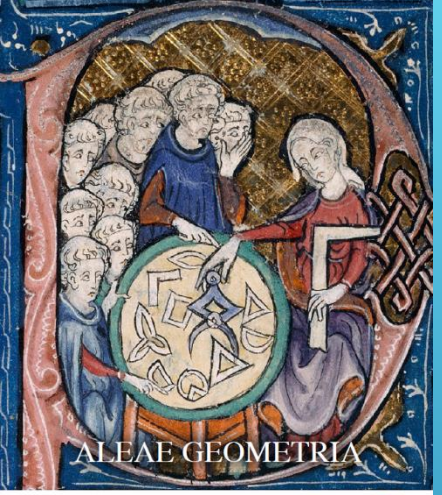
- Broniatowski, Michel. ***Minimum divergence estimators, Maximum Likelihood and the generalized bootstrap,*** to appear in «Divergence Measures: Mathematical Foundations and Applications in Information-Theoretic and Statistical Problems» Entropy, 2020
- Csiszár, Imre ; Gassiat, Elisabeth. ***MEM pixel correlated solutions for generalized moment and interpolation problems.*** IEEE Trans. Inform. Theory 45, no. 7, 2253–2270, 1999
- Liese, Friedrich; Vajda, Igor. ***On divergences and informations in statistics and information theory.*** IEEE Trans. Inform. Theory 52, no. 10, 4394–4412, 2006



5th GSI'21 Conference

LEARNING GEOMETRIC STRUCTURES

Sorbonne University

July 21st -22nd- 23rd 2021

Max Welling

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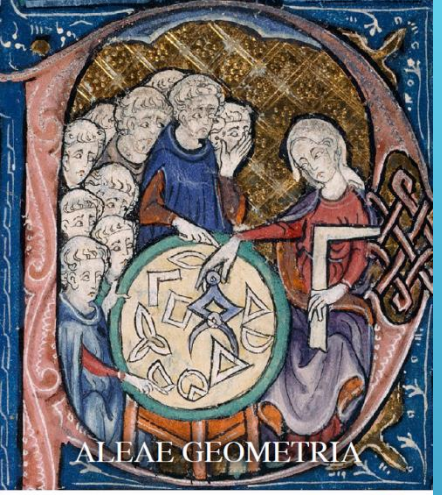
TITLE: EXPLORING QUANTUM STATISTICS FOR MACHINE LEARNING

Abstract:
Quantum mechanics represents a rather bizarre theory of statistics that is very different from the ordinary classical statistics that we are used to. In this talk I will explore if there are ways that we can leverage this theory in developing new machine learning tools: can we design better neural networks by thinking about entangled variables?
Can we come up with better samplers by viewing them as observations in a quantum system? Can we generalize probability distributions? We hope to develop better algorithms that can be simulated efficiently on classical computers, but we will naturally also consider the possibility of much faster implementations on future quantum computers. Finally, I hope to discuss the role of symmetries in quantum theories.

References:
- Roberto Bondesan, Max Welling, ***Quantum Deformed Neural Networks***, arXiv:2010.11189v1 [quant-ph], 21st October 2020 ; https://arxiv.org/abs/2010.11189



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Jean Petitot

Directeur d'Études, Centre d'Analyse et de Mathématiques, Sociales, École des Hautes Études, Paris.

TITLE : THE PRIMARY VISUAL CORTEX AS A CARTAN ENGINE

Abstract:
Cortical visual neurons detect very local geometric cues as retinal positions, local contrasts, local orientations of boundaries, etc. One of the main theoretical problem of low level vision is to understand how these local cues can be integrated so as to generate the global geometry of the images perceived, with all the well-known phenomena studied since Gestalt theory. It is an empirical evidence that the visual brain is able to perform a lot of routines belonging to differential geometry. But how such routines can be neurally implemented ? Neurons are « point-like » processors and it seems impossible to do differential geometry with them. Since the 1990s, methods of «in vivo optical imaging based on activity-dependent intrinsic signals» have made possible to visualize the extremely special connectivity of the primary visual areas, their "functional architectures." What we called « Neurogeometry » is based on the discovery that these functional architectures implement structures such as the contact structure and the sub-Riemannian geometry of jet spaces of plane curves. For reasons of principle, it is the geometrical reformulation of differential calculus from Pfaff to Lie, Darboux, Frobenius, Cartan and Goursat which turns out to be suitable for neurogeometry.

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- Citti, G., Sarti, A., A ***cortical based model of perceptual completion in the roto-translation space,*** Journal of Mathematical Imaging and Vision, 24, 3 (2006) 307-326.
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