

6th International Conference on
**GEOMETRIC SCIENCE
OF INFORMATION**

GSI'23

Saint-Malo, France

30th August to 1st September 2023

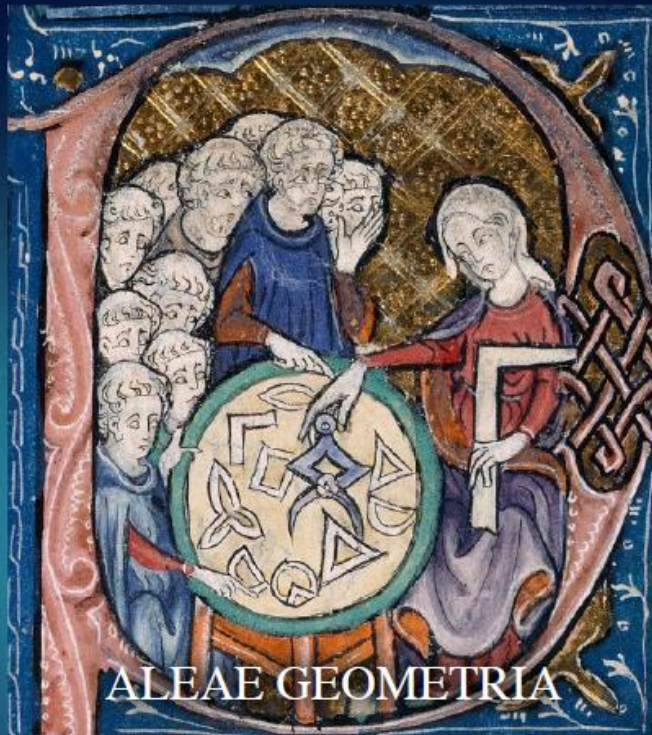


6th Conference on the
**Geometric Science
of Information**

GSI'23

FROM CLASSICAL TO QUANTUM INFORMATION GEOMETRY

Saint-Malo, 30th August to 1st September 2023



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10 years anniversary

6th International Conference on
**GEOMETRIC SCIENCE
OF INFORMATION**

GSI'23

Saint-Malo, France

30th August to 1st September 2023



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GSI'23
Saint-Malo, France
30th August to 1st September 2023

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Frank Nielsen
(Sony Computer Science Laboratories Inc.)
www.sony CSL.co.jp/member/tokyo/164

GSI'23 ORGANIZER



THE GSI'23 CONFERENCE IS
DEDICATED TO THE MEMORY OF
MADemoiselle PAULETTE
LIBERMANN, GEOMETER STUDENT
OF ELIE CARTAN AND ANDRÉ
LICHNEROWICZ, PHD STUDENT OF
CHARLES EHRESMANN AND
FAMILIAR WITH THE EMERALD
COAST OF FRENCH BRITTANY.

► After her PhD, she was appointed professor at the **University of Rennes** and after at the Faculty of Sciences of the University of Paris in 1966. she studied the **Symplectic manifolds provided with two transverse Lagrangian foliations and showed the existence, on the leaves of these foliations, of a canonical flat connection**. Libermann also deepened the importance of the foliations of a symplectic manifold which she called "**symplectically complete**", such as the Poisson bracket of two functions, locally defined, that is also constant on each leaf

She wrote a famous **book with Professor Charles-Michel Marle "Symplectic Geometry and Analytical Mechanics"**. Professor Charles-Michel Marle told us that Miss Paulette Libermann had bought **an apartment in Dinard** and spent her summers just in front of Saint-Malo, and so was familiar with the emerald coast of French Brittany.



**Paulette Libermann
on Dinard Beach in Front
of Saint-Malo**

PAULETTE LIBERMAN STUDENT OF ANDRE LICHNEROWICZ AT ENS SEVRE



PAULETTE LIBERMANN AT 1953 « GÉOMÉTRIE DIFFÉRENTIELLE » CONFERENCE IN STRASBOURG



J.L. Koszul



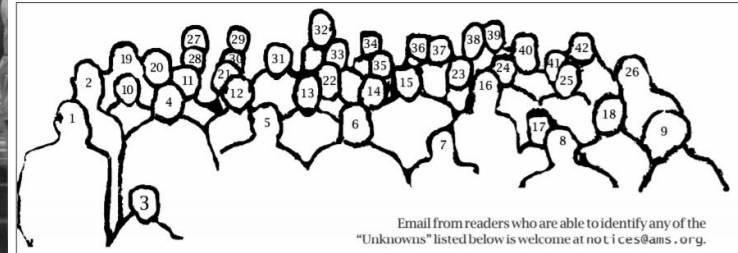
G. Reeb



J.M. Souriau



P. Libermann



Email from readers who are able to identify any of the "Unknowns" listed below is welcome at notes@ams.org.

Key to photo on page 367.

1. Unknown
2. R. Debever
3. Ehresmann's son
4. Shiing-Shen Chern
5. André Lichnerowicz
6. Charles Ehresmann
7. Paulette Libermann
8. Mario Villa
9. Lucien Godeaux
10. Heinz Hopf

11. Wilhelm Süss
12. Laurent Schwartz
13. Georges de Rham
14. Unknown
15. H. Guggenheimer
16. Thomas Willmore
17. Simone Lemoine
18. B. H. Neumann
19. René Thiry
20. E. T. Davies
21. Unknown

22. Unknown
23. Unknown
24. Unknown
25. Nicolaas Kuiper
26. Beno Eckmann
27. Unknown
28. Jean-Louis Koszul
29. Unknown
30. André Weil
31. René Thom
32. John Milnor

33. Marcel Berger
34. Unknown
35. Bernard Malgrange
36. Daniel Bernard
37. André Aragnol
38. G. Legrand
39. Jean-Marie Souriau
40. Unknown
41. Georges Reeb
42. Unknown

"We have above all endeavored to highlight some of the new paths in which our science is going. We also wanted young mathematicians to be able to highlight their reflections and their results" - Ehresmann & Lichnerowicz 1953

PARTICIPANTS TO 1953 CONFERENCE

Organizer

- ▶ **Charles Ehresmann**, University of Strasbourg, France.
- ▶ **André Lichnerowicz**, Collège de France.

Participants

- ▶ E. Bampiani, Roma, Italy.
- ▶ **S. S. Chern**, Chicago, USA.
- ▶ E. T. Davies, Southampton, England.
- ▶ P. Dedecker, Brussels, Belgium.
- ▶ B. Eckmann, Zürich, Switzerland.
- ▶ E. Heinz, Göttingen, Germany.
- ▶ N. H. Kuiper, Wageningen, Netherlands.
- ▶ H. Rund, Bonn, Germany.
- ▶ M. Villa, Bologna, Italy.
- ▶ T. J. Willmore, Durham, England.
- ▶ **J. L. Koszul**, Strassbourg, France.
- ▶ **Paulette Libermann**, Strasbourg, France.
- ▶ **G. Reeb**, Grenoble, France.
- ▶ **L. Schwartz**, Paris, France.
- ▶ **J. M. Souriau**, Tunis, France.
- ▶ **R. Thom**, C.N.R.S., France.
- ▶ **A. Weil**, Chicago, USA.
- ▶ A. Aragnal, Paris, France.
- ▶ **M. Berger**, Paris, France.
- ▶ D. Bernard, Paris, France.
- ▶ C. de Carvalho, Rio de Janeiro, Brazil.
- ▶ C. Chabauty, Strassbourg, France.
- ▶ G. Cerf, Strassbourg, France.
- ▶ R. Debever, Brussels, Belgium.
- ▶ M. Decuyper, Lille, France.
- ▶ J. Deny, Strasbourg, France.
- ▶ A. Frölicher, Zürich, Switzerland.
- ▶ **F. Gallissot**, Grenoble, France.
- ▶ L. Godeaux, Liège, Belgium.
- ▶ H. Guggenheimer, Bôle, Switzerland.
- ▶ R. Guy, Neuchâtel, Switzerland.
- ▶ M. Heins, Brown University, USA.
- ▶ R. Hermann, Amsterdam, Netherlands.
- ▶ **H. Hopf**, Zürich, Switzerland.
- ▶ M. Iss, Strasbourg, France.
- ▶ F. Jongmans, Liège, Belgium.
- ▶ G. Legrand, Paris, France.
- ▶ S. Lemoine, Paris, France.
- ▶ J. Loiseau, Paris, France.
- ▶ M. Lyra, Sao Paolo, Brazil.
- ▶ B. Malgrange, Paris, France.
- ▶ **J. Milnor**, Zürich, Switzerland.
- ▶ R. Piedvache, Poitiers, France.
- ▶ **G. de Rham**, Lausanne, Switzerland.
- ▶ M. H. Schwartz, Paris, France.
- ▶ H. B. Shurtrick, Liverpool, England.
- ▶ E. H. Spanier, Chicago, USA.
- ▶ W. Süss, Freiburg, Germany.
- ▶ Y. Thiry, Tunis, France.

WE WILL ALSO DEDICATE GSI'23 TO PROFESSOR Calyampudi Radhakrishna RAO WHO PASSED AWAY LAST WEEK (102 YEARS OLD) THE FOUNDER OF INFORMATION GEOMETRY

C.R. Rao, "Information and accuracy attainable in the estimation of statistical parameters",
Bulletin of the Calcutta Mathematical Society, Vol.37, No.3, pp.81–91, 1945

Information and the Accuracy Attainable in the Estimation of Statistical Parameters

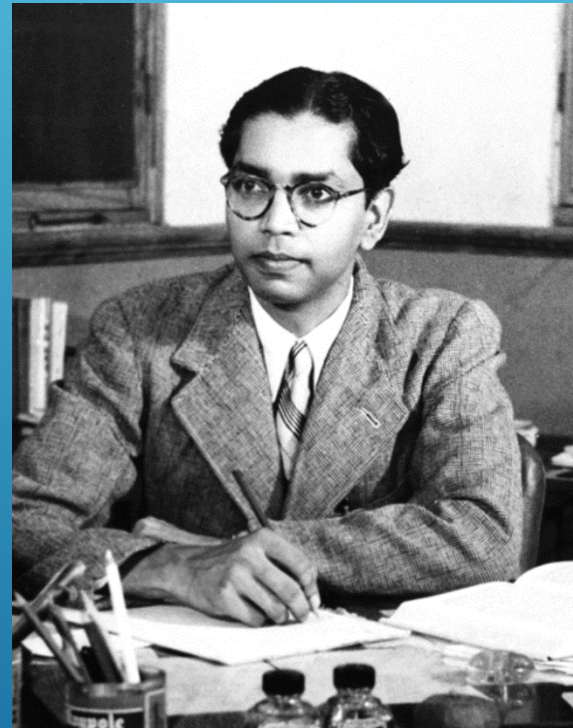
C Radhakrishna Rao

(Communicated by Mr. R C Bose—Received August 23, 1945)

Introduction

The earliest method of estimation of statistical parameters is the method of least squares due to Markoff. A set of observations whose expectations are linear functions of a number of unknown parameters being given, the problem which Markoff posed for solution is to find out a linear function of observations whose expectation is an assigned linear function of the unknown parameters and whose variance is a minimum. There is no assumption about the distribution of the observations except that each has a finite variance.

A significant advance in the theory of estimation is due to Fisher (1921) who introduced the concepts of *consistency*, *efficiency* and *sufficiency* of estimating functions and advocated the use of the maximum likelihood method. The principle accepts as the estimate of an unknown parameter θ , in a probability function $\phi(\theta)$ of an assigned type, that function $t(x_1, \dots, x_n)$ of the sampled observations which makes the probability density a maximum. The validity of this principle arises from the fact that out of a large class of unbiased estimating functions following the normal distribution the function given by maximising the probability density has the least variance. Even when the distribution of t is not normal the property of minimum variance tends to hold as the size of the sample is increased.



"The latest count of the number of international conferences I attended is close to 200. The first one was the *Colloquium on Probability and Statistics held in Lyon, France, in 1948. There, I met Doob, Fréchet, and a few other well-known probabilists. I also met LeCam, who was still a student planning to go to the United States for higher studies.*" – C.R. Rao (Interview by Anil K. Bera)

1. G. Ottaviani (Italy): *The Uniform Law of Large Numbers in the Classic Theory of Probability.*
2. J. L. Doob (USA): *Application of the Theory of Martingales.*
3. D. van Dantzig (Holland): *On the Method of Generating Functions.*
4. H. Wold (Sweden): *On Stationary Point Processes.*
5. J. Wishart (UK): *Test of Homogeneity of Regression Coefficients.*

1. G. Darmon: *On Certain Forms of Relations of Probabilities.*
2. M. Fréchet: *The Typical Values of Order Zero or Infinity of a Random Number and Their Generalization.*
3. P. Lévy: *Double Markov Processes.*
4. A. Blanc Lapierre: *Considerations on the analysis of random functions.*
5. J. Kampé de Fériet: *Stationary Random Functions and Transformation Groups in an Abstract Space.*
6. E. Halphen: *On the Problem of Estimation.*
7. P. Delaporte: *On the Use of Systematics of Mathematical Statistics in Factorial Analysis.*
8. R. Fortet: *Probability of Loss of a Telephone Call.*
9. J. Ville: *Random Functions and Transmission of Information.*
10. G. Malécot: *Stochastic Processes and Genetics.*
11. H. Eyraud: *Pure Economy. Credit and Speculation.*

C. R. Rao, who did not present a lecture, participated in all the meetings and intervened several times, once following the exposition of Doob... Only Rao asked Doob a question, relating to a problem of nonparametric statistics in the framework of martingales. ..After Doob's presentation, only Calyampudi Radhakrishna Rao rose to ask questions, on the possibility of applying the method without an a priori distribution for θ , as in the nonparametric case.

APPLICATION OF THE THEORY OF MARTINGALES

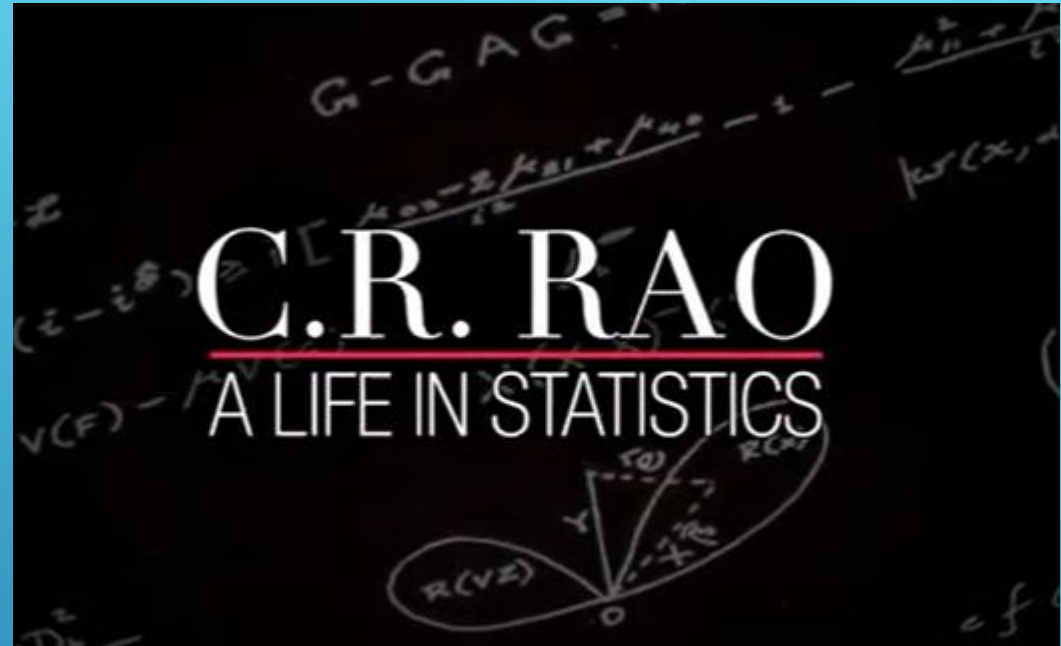
by J. L. DOOB,
(Urbana, Ill., U. S. A.)

Doob at Lyon. On his lecture, Application of the Theory of Martingales, at the Lyon Colloquium, June 28 – July 3, 1948, Bernard LOCKER



Fig. 9 Colloque International sur le Calcul des Probabilités, Lyon 1948. First row: Paul Lévy and Maurice Fréchet. On the picture one can find among others J. Doob, R. Fortet, D. Van Dantzig, E. Mourier, J. Kampé de Fériet, A. Blanc-Lapierre. . . (Photo: © Private collection F. Lederer)

<https://www.youtube.com/watch?v=eaxjUxoCx5w>



C.R. RAO (100TH BIRTHDAY VIDEO)

F. Nielsen page on C.R. Rao: <https://franknielsen.github.io/CRRao/>

SUR L'EXTENSION DE CERTAINES EVALUATIONS
STATISTIQUES AU CAS DE PETITS ECHANTILLONS

par Maurice Fréchet.

[1943, univariate]



Maurice Fréchet
(1878-1973)

Information and the Accuracy Attainable
in the Estimation of Statistical Parameters

C. Radhakrishna Rao

[1945, multivariate, Rao distance]



Calyampudi Radhakrishna Rao

The
Fréchet-Darmois
Cramér-Rao
lower bound

$$\text{Var}[\hat{\theta}_n] \succeq \frac{1}{n} I^{-1}(\theta)$$

SUR LES LIMITES
DE LA DISPERSION DE CERTAINES ESTIMATIONS

par G. Darmois

[1945, multivariate]



Georges Darmois
(1888-1960)

A Contribution to the Theory of Statistical
Estimation.

By Harald Cramér (Stockholm).

[1946, multivariate]



Harald Cramér
(1893-1983)

Institut de France Academie des Sciences

In collaborating in the collection of memoirs which are going to be dedicated in homage to you I have given expression to the high esteem in which I hold your scientific works and their applications and the advancements which you have made in the education and application of statistics in India.

I can assure you without going in for votes (and I have been authorised to inform you) that the sentiments which I have expressed are also shared by my co-workers in the Academy of Sciences. We also hope that the bonds of friendship which have been forged between your great country and ours during the past years may continue being strengthened. Permit me, my dear colleague, to express my most cordial and best regards for you.



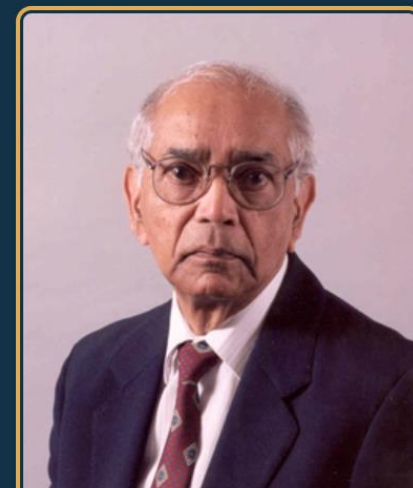
Maurice Fréchet



Eminent Statistician C.R. Rao Awarded 2023 International Prize in Statistics

C.R. Rao, a professor whose work more than 75 years ago continues to exert a profound influence on science, has been awarded the 2023 International Prize in Statistics.

In his remarkable 1945 paper published in the *Bulletin of the Calcutta Mathematical Society*, Callyampudi Radhakrishna (C.R.) Rao demonstrated three fundamental results that paved the way for the modern field of statistics and provided statistical tools heavily used in science today.



Fisher-Rao Riemannian geometry (Hotelling precursor)

Metric tensor = **Fisher information metric**

$$g_{jk}(\theta) = \int_X \frac{\partial \log p(x, \theta)}{\partial \theta_j} \frac{\partial \log p(x, \theta)}{\partial \theta_k} p(x, \theta) dx.$$

Infinitesimal squared length element:

$$ds^2 = \sum_{ij} g_{ij}(\theta) d\theta_i d\theta_j = d\theta^T I(\theta) d\theta$$

Fisher-Rao distance satisfying the metric axioms:

$$\rho(p(x; \theta_1), p(x; \theta_2)) = \min_{\substack{\theta(s) \\ \theta(0)=\theta_1 \\ \theta(1)=\theta_2}} \int_0^1 \sqrt{\left(\frac{d\theta}{ds}\right)^T I(\theta) \frac{d\theta}{ds}} ds$$

Geodesic length distance
(shortest path)

- Statistical data analysis and inference, Yadolah Dodge (Ed), 1989
- An elementary introduction to information geometry, arXiv:1808.08271
- Cramér-Rao Lower Bound and Information Geometry, Connected at Infinity II, 2013 - Springer



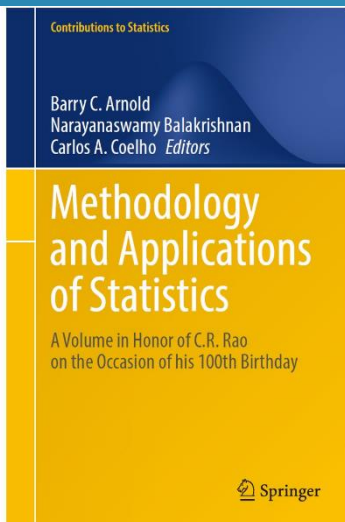
Dr. C. R. Rao on his 100th birthday



Dr. C. R. Rao with his daughter Dr. Rajendra Rao on his 100th birthday
Photo courtesy of Dr. Rajendra Rao



C. R. Rao with Sir R. Fisher
in 1956



C.R. RAO AND INFORMATION GEOMETRY JOURNAL EDITED BY SPRINGER

EDITORIAL



CrossMark

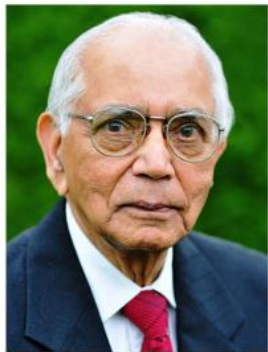
Congratulatory message

Calyampudi Radhakrishna Rao¹

Published online: 19 September 2018
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I am glad to know that Springer is starting a new journal with the title of *Information Geometry* under the chief editorship of Shinto Eguchi with co-editors Nihat Ay, Frank Nielsen, and Jun Zhang. The journal is interdisciplinary, integrating various disciplines, especially branches of mathematical sciences related to the field of information geometry. This is a needed area of literature, and the journal meets that requirement.

Congratulations and best wishes for the success of the journal.



C. R. Rao

C.R. Rao

Information Geometry

Volume 4 · Number 1 · 2021

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<https://link.springer.com/article/10.1007/s41884-018-0010-8>

C.R. RAO EDITOR OF HANDBOOK OF STATISTICS

N°46 « GEOMETRY & STATISTICS »

handbook of statistics 46

Geometry and Statistics

Edited by
Frank Nielsen
Arni S.R. Srinivasa Rao
C.R. Rao



September 2022

•Part I: Foundations in Classical Geometry and Analysis

- **Geometry, Information and Complex Bundles**
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- **Equivalence Relations and Inference for Sparse Markov Models**
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- **Symplectic Theory of Heat and Information Geometry**
by Frédéric Barbaresco
- **Unifying Framework for Some Directed Distances in Statistics**
Michel Broniatowski and Wolfgang Stummer
- **The analytic dually flat space of the mixture family of two prescribed distinct Cauchy distributions**
by Frank Nielsen
- **Local Measurements of Non-linear Embeddings with Information Geometry**
by Ke Sun

•Part III: Advanced Geometrical Intuition and Analysis

- **Parallel transport, a central tool in geometric statistics for computational anatomy. Application to cardiac motion modelling**
by Nicolas Guigui and Xavier Pennec
- **Geometry and Mixture Models**
by Paul Marriott
- **Gaussian distributions on Riemannian symmetric spaces of non-positive curvature**
by Salem Said, Cyrus Mostajeran, and Simon Heuveline
- **Multilevel contours on bundles of complex planes**
by Arni S.R. Srinivasa Rao

Geometric Science of Information

Georg F. B. Riemann (1826-1866)
metric tensor (1854)
 $g = g_{ij}d\theta_i \otimes d\theta_j$
Riemannian manifold (M, g)

Élie Joseph Cartan (1869-1951)
affine connections
differential forms ω

Blaise Pascal (1623-1662)
Alone Geometria
Probability
Thermodynamics (pression Pa.)
Computer (Pascaline)

Rabindra Nath Sen (1896-1974)
dual parallel transports
(ca. 1945-1950)

Alexander P. Norden (1904-1993)
conjugate connections wrt g
Affinely connected spaces

Sir Ronald A. Fisher (1890-1962)
Mathematical statistics
Fisher information, MLE
 $I(\theta) = E_{p_\theta} [(\nabla_\theta \log p_\theta)(\nabla_\theta \log p_\theta)^T]$

Sir Harold Jeffreys (1891-1989)
Jeffreys prior $\propto \sqrt{|g|}$
J-divergence

Maurice R. Fréchet (1878-1973)
Metric spaces
Fréchet barycenter
Fréchet CR bound
Legendre-Clairaut structure

Wilhelm J. E. Blaschke (1885-1962)
Affine differential geometry

Harold Hotelling (1895-1973)
Econometrician
Fisher metric
(1930)

Claude E. Shannon (1916-2001)
Information theory
Entropy:
 $h(p) = -\int p \log p d\mu$

Imre Csiszár (1938-)
information projections
f-divergences
 $I_f[p : q] = \int p f(\frac{p}{q}) d\mu$

C. R. Rao (1920-)
Fisher-Rao distance
Cramér-Rao lower bound
(1945)

Solomon Kullback (1907-1994)
Richard A. Leibler (1914-2003)
KL divergence
 $D_{KL}[p : q] = \int p \log \frac{p}{q} d\mu$

Ernest B. Vinberg (1937-2020)
characteristic functions
on homogeneous cones

Harald Cramér (1893-1985)

Nikolai N. Chentsov (1930-1992)
statistical invariance
geometrostatistics
Gen. Pythagoras theorem
 $D(P : Q) + D(Q : R) = D(P : R)$

Bradley Efron (1938-)
statistical curvature
E-connection
Lev M. Bregman (1941-)
Bregman divergence
Bregman projections

Ole E. Barndorff-Nielsen (1935-)
Exponential families
observed information geometry

Jean-Louis Koszul (1921-2018)
Hirohiko Shima
Hessian Geometry
Symmetric Homogeneous Bounded Domains
Koszul forms, Fisher metric extension for sharp convex cones
Lie Algebra Cohomology, Koszul Complex, Koszul duality, Koszul connection
homogeneous bounded domains

Philip Dawid (1946-)
decision theory
proper scoring rules

Steffen Lauritzen (1947-)
statistical manifold
graphical models

Jean-Marie Souriau (1922-2012)
Lie Groups Thermodynamics
Souriau 2-form, Moment map
Fisher metric extension on
Homogeneous Symplectic Manifolds
Lie Groups Statistics, Entropy as Casimir Function
Fisher Metric as calorific capacity

Shun-ichi Amari (1936-)
Information geometry
dualistic structure $(M, g, \nabla^*, \nabla^*)$:
 $Z_g(X, Y) = g(\nabla_X Y, Y) + g(X, \nabla_Y Y)$
dual $\pm\alpha$ -connections
 $(M, g_F, \nabla^{-\alpha}, \nabla^\alpha)$

« Tomorrow never dies »
the GSI community will continue to contribute to the development of Geometric Science of Information

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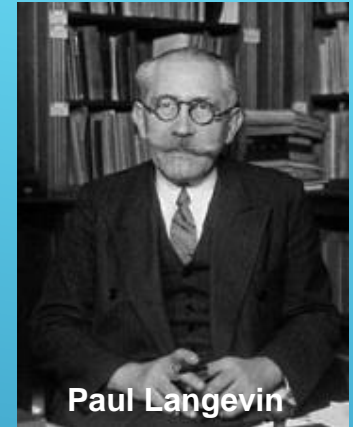
GSI'23 EDITORS



SEE at a glance



- Meeting place for science, industry and society
- An officially recognised non-profit organisation
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- 19 «Clubs techniques» and 12 «Groupes régionaux»
- Organizes conferences and seminars
- Initiates/attracts International Conferences in France
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- 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

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1881

Exposition Internationale d'Electricité



**1883: SIE
Société
Internationale
des Electriciens**

**1886: SFE
Société
Française
des Electriciens**



2023: SEE

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75783 Paris Cedex 16**



WP5: The geometry of Deep Learning

Main research themes:

- Lie groups thermodynamics
- Persistent Homology and Geneos
- The geometry of (Geometric) Deep Learning

Key People:

[Rita Fioresi](#)

(UNIBO)

[Frédéric Barbaresco](#)

(Thales)

CaLIGOLA

Cartan geometry, Lie and representation theory, Integrable Systems, quantum Groups and quantum computing towards the understanding of the geometry of deep Learning and its Applications

Programme: Horizon Europe Framework Programme (HORIZON)

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Project ID: 101086123

details

CaLIGOLA aims at advancing the research in Cartan Geometry, Lie Theory, Integrable Systems and Quantum Groups to provide insight into a variety of multidisciplinary fields oriented towards the applications with a special interest in machine learning and quantum computing. Sound mathematical models for quantum computing, vision and more generally machine learning are a priority for Horizon Europe and strategic to include Europe among the leading actors in such fields. Through the theory of symmetric spaces from the Cartan Geometric and Lie theoretic point of view, we shall implement the Erlangen philosophy for mathematical and physical questions (integrable systems and SUSY gauge field theory), but also for more applied themes including Quantum Computing and (geometric) Deep Learning. Quantum symmetric spaces and quantum representations will be the key to approach the questions of fault tolerant quantum algorithms in topological quantum computing and quantum information geometry on homogeneous spaces. With the language of Cartan geometry and Quantum Groups, we shall reformulate group invariant neural network models. Persistent homology and topological data analysis will take a step forward towards a metric theory on the space of observers. With the help of Lie group thermodynamic, we shall push the understanding of symmetries at a deeper level. Overall, the new algorithms of Deep Learning and Geometric Deep Learning will find a better modeling and understanding towards a comprehensive theory of dimensionality reduction of parameter space via group equivariance.

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WG4 Workshop, Mines ParisTech, **July 2024, PARIS**

- Symmetry and equivariance in Deep Learning and Geometry-Informed Neural Network
- Symplectic Model of Lie Groups Thermodynamics & Deep Learning on Lie Groups
- Maxplus algebra, tropical geometry and mathematical morphology in Deep Learning

CA21109 – COST Action CaLISTA – How to participate in the Action

Cartan geometry, Lie, Integrable Systems, quantum group Theories for Applications - CaLISTA aims to advance cutting-edge research in mathematics and physics through a systematic application of the ideas and philosophy of Cartan geometry, a thorough Lie theoretic approach to differential geometry.

WG4: Vision models

VISION

In this WG we focus on the study of new models to advance in our understanding of vision in the framework of the new techniques as deep learning (DL), geometric deep learning (GDL).

CONTACTS

Jesus Angulo
MINES Paris, France
[Write an e-mail](#)

Aims of the Project

Symmetry is a central unifying theme in mathematics and physics.

In this project we focus our attention on symmetries realized through Lie groups and Lie algebras.

In addition to the spectacular achievements in representation theory, and differential geometry, Lie theory is also exceptionally important for the formalization of fundamental physical theories.

CaLISTA aims to advance cutting-edge research in mathematics and physics through a systematic application of the ideas and philosophy of Cartan geometry, a thoroughly Lie theoretic approach to differential geometry.

In addition to making major progress in Cartan geometry itself, CaLISTA aims to develop crucial applications to integrable systems and supersymmetric gauge theories.

Quantum groups and their quantum homogeneous spaces come into the play as a bridge between these topics: quantum groups stem originally from the R-matrix formulation in integrable systems, and their homogeneous spaces offer prototypical examples of noncommutative parabolic geometries.

Parabolic geometry is the first and possibly the most important example of Cartan geometry, and one of the main aims of CaLISTA is to obtain a quantum generalization.

Surprisingly, Lie theory and Cartan geometry play a role in an exciting new interpretation of the differential structure, and related dynamics, of models for popular algorithms of vision like Deep Learning and the more recent Geometric Deep Learning.

CaLISTA aims to investigate and improve on these techniques. CaLISTA will provide essential mathematical models with far-reaching applications, placing Europe among the leading actors in these innovative research areas.

EU COST Action CaLIGOLA:
<https://site.unibo.it/calista/en>

THALES: A RESEARCH AND DEVELOPMENT POWERHOUSE



Albert Fert

Scientific director of the CNRS/Thales joint physics unit and winner of the **2007 Nobel prize in physics**.



10 times winner

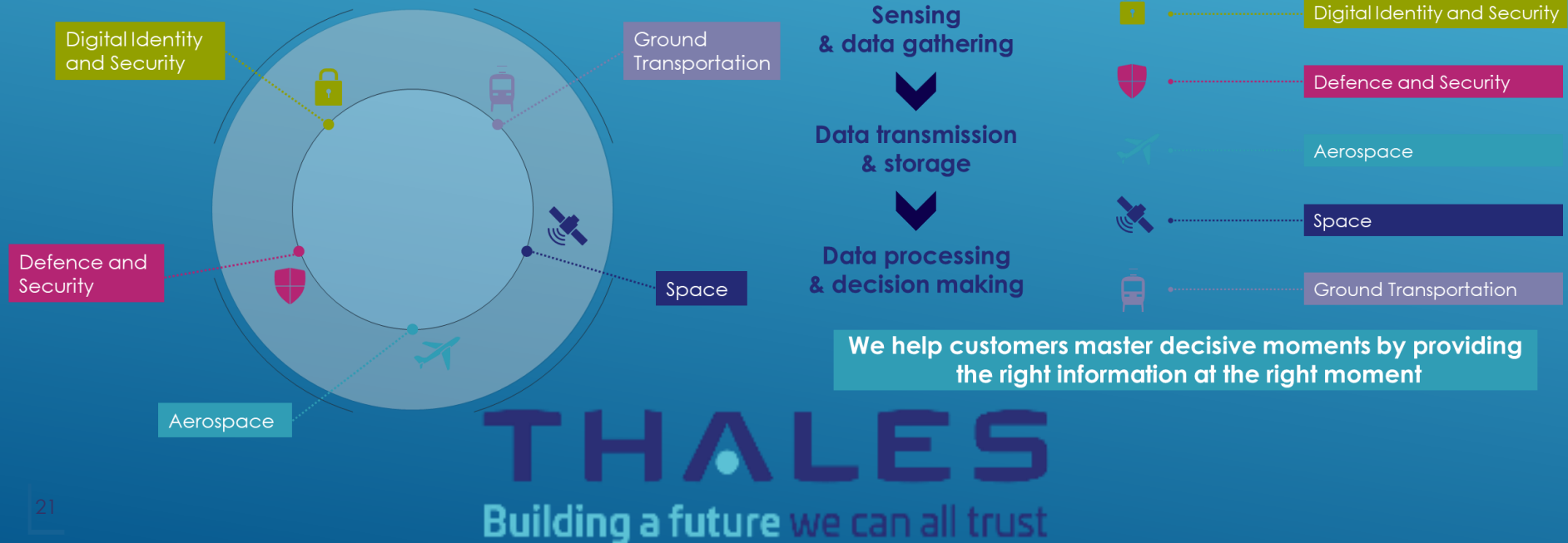
2013, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023



Expertise in a uniquely broad range of technical domains, from science to systems, applied across businesses.



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GSI'23 Figures

- **GSI'23 Registrations:** 195 participants
- **GSI'23 Program**
 - 6 Keynote Speakers
 - 134 talks in 25 Oral sessions
 - 19 Posters in 1 Poster session
- **Papers Acceptance Rate of 83% based on 113 reviewers (minimum of 2 reviews per paper)**
- **Papers Origin:** France, Germany, USA, Japan , UK, Denmark, Netherlands, Australia, Austria, Belgium, Canada, Norway, Portugal, Romania, Spain, Sweden, Switzerland, ...

Conference Co-chairs:

- **Frank Nielsen**, Sony Computer Science Laboratories Inc., Japan
- **Frédéric Barbaresco**, President of SEE ISIC Club, Thales Land & Air Systems, Velizy-Villacoublay, France

Local organizing committee:

- **SEE** Groupe Régional GRAND OUEST
- **Christophe LAOT**, SEE & IMT Atlantique
- **Alain ALCARAS**, SEE & THALES SIX
- **Jacques CLAVERIE**, SEE & CREC St-Cyr Côtéquidan
- **Palais du Grand Large Team**, Saint-Malo

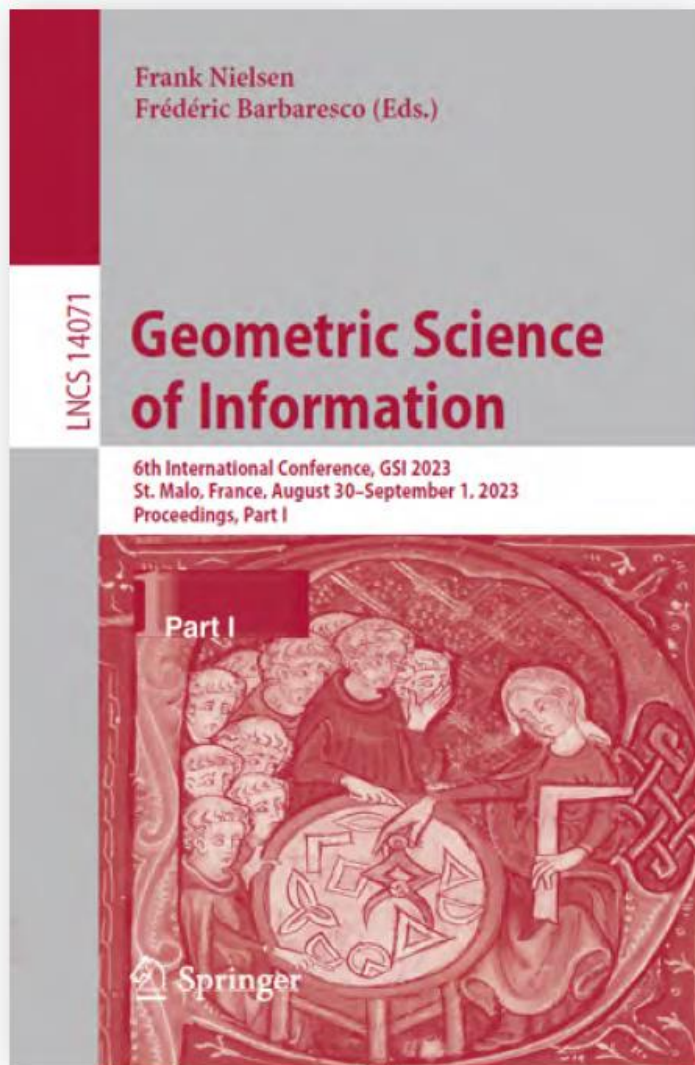
Secretariat:

- **Mrs. Imene AHMED**, SEE, France

Scientific committee:

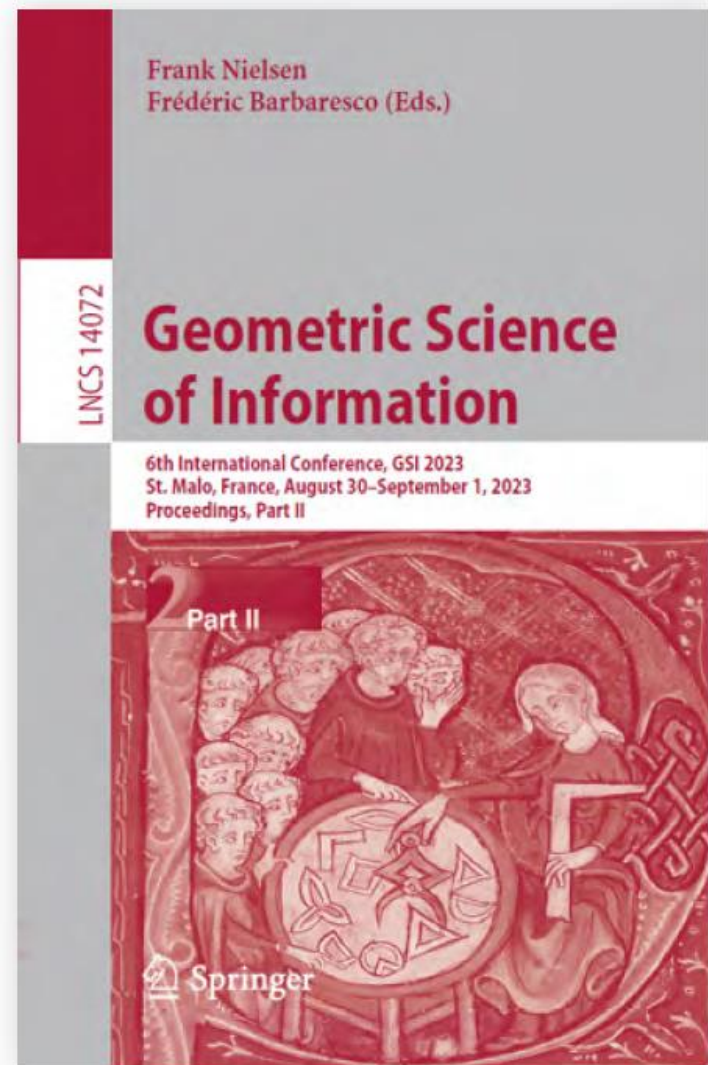
- **Bijan Afsari**, Johns Hopkins University
- **Pierre-Antoine Absil**, Université Catholique de Louvain
- **Jesus Angulo**, Mines ParisTech
- **Nihat Ay**, Max Planck Institute
- **Simone Azeglio**, ENS Paris
- **Frédéric Barbaresco**, Thales Land & Air Systems
- **Pierre Baudot**, Median Technologies
- **Daniel Bennequin**, Paris-Diderot University
- **Pierre Bieliavsky**, Université de Louvain
- **Michel Boyom**, Montpellier University
- **Goffredo Chirco**, Theoretical Physics Group INFN, Naples
- **Florio M. Ciaglia**, Max Planck Institute
- **Patrick Clarysse**, INSA Lyon & CREATIS
- **Nicolas Couellan**, ENAC
- **Ana Bela Ferreira Cruzeiro**, Universidade de Lisboa
- **Ariana Di Bernardo**, ENS Paris
- **Remco Duits**, Eindhoven University of Technology
- **Fabrice Gamboa**, Institut Mathématique de Toulouse
- **Jean-Pierre Gazeau**, Paris Diderot University
- **François Gay-Balmaz**, ENS Paris
- **Wuchen Li**, UCLA
- **Audrey Giremus**, Bordeaux University
- **Hatem Hajri**, IRT SsystemX, Paris-Saclay
- **Bruno Iannazzo**, Università degli Studi di Perugia
- **Hideyuki Ishi**, Osaka City University
- **Stéphanie Jehan-Besson**, CREATIS, CNRS UMR 5220
- **Pierre-Yves Lagrave**, Morgan Stanley
- **Manuel de Leon**, Real Academia de Ciencias, Madrid
- **Jean Lerbet**, Evry University
- **Nicolas Le Bihan**, Grenoble University
- **Luigi Malago**, Romanian Institute of Science and Technology
- **Jonathan Manton**, The University of Melbourne
- **Gaetan Marceau-Caron**, MILA R&D and Tech Transfer
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- **Jean-François Marcotrichino**, Sorbonne University
- **Charles-Michel Marle**, Sorbonne University
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- **Hiroshi Matsuzoe**, Nagoya Institute of Technology
- **Nina Miolane**, UC Santa Barbara
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- **Frank Nielsen**, Sony Computer Science Laboratories Inc, Japan
- **Richard Nock**, Université Antilles-Guyane
- **Yann Ollivier**, FACEBOOK FAIR Paris
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- **Giovanni Pistone**, CarloAlberto University
- **Gery de Saxcé**, Lille University
- **Salem Said**, Bordeaux University
- **Rodolphe Sepulchre**, Liège University
- **Stefan Sommer**, Copenhagen University
- **Wolfgang Stummer**, University of Erlangen-Nürnberg
- **Daisuke Tarama**, Ritsumeikan University
- **Koichi Tojo**, RIKEN Tokyo
- **Zdravko Terze**, University of Zagreb
- **Alain Trounev**, Ecole Normale Supérieure Paris-Saclay
- **Alice Barbara Tumpach**, Université de Lille
- **Hong Van Lê**, Institute of Mathematics of Czech Academy of Sciences
- **Geert Verdoolaege**, Ghent University
- **Hiroaki Yoshimura**, Waseda University
- **Jean Claude Zambrini**, Universidade de Lisboa
- **Jun Zhang**, University of Michigan, Ann Arbor

GSI'23 Proceedings



GSI23 Part I

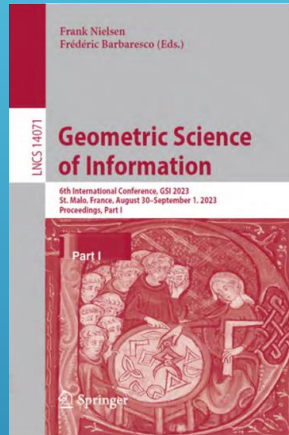
<https://link.springer.com/book/9783031382703>



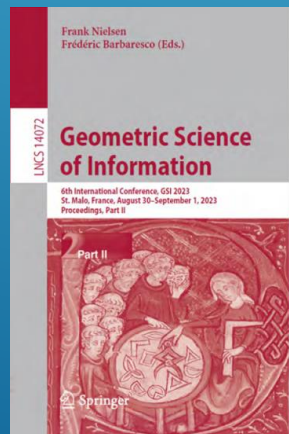
GSI23 Part II

<https://link.springer.com/book/9783031382987>

GSI 2023 SPRINGER LNCS Proceedings free online access starting from August 25



Part I: <https://link.springer.com/book/10.1007/978-3-031-38271-0>



Part II: <https://link.springer.com/book/10.1007/978-3-031-38299-4>

Dear GSI session Organizer,

We are delighted to announce that in partnership with the Springer Nature Information Geometry (INGE) journal: <https://www.springer.com/journal/41884>

We are launching a special issue of selected papers of Geometric Science of Information (GSI'23): <https://conference-gsi.org/>

See) <https://www.springer.com/journal/41884/updates/24084742>

The first invited paper just got published with free PDF access:

<https://link.springer.com/article/10.1007/s41884-023-00111-2>

Long papers extended contributions accepted to GSI'23 will be submitted via <https://www.editorialmanager.com/inge/default2.aspx> by selecting GSI23 Special issue

Publication is free of charge with optional paid open access which can be waived depending on whether your institute belongs to Springer program <https://www.springernature.com/gp/open-research/institutional-agreements> // <https://www.springer.com/journal/41884/how-to-publish-with-us#Fees%20and%20Funding>

Notice that peer-reviewing of the special GSI'23 issue of INGE is ***independent of the peer-reviewing of GSI'23***. When submitting to this special issue, please provide a list of 5 potential reviewers (with emails and affiliations, web pages). Accepted papers will be published online first and a GSI volume with print edition will be issued upon completion of the GSI'23 SI.

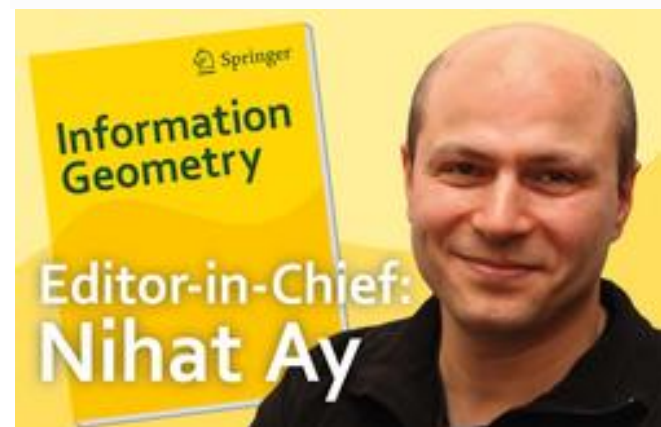
Deadlines for submitting to the special issue:

- Opening: July 15th 2023
- Closing: December 31st 2023

We kindly ask session Chairs to identify their most novel high-quality papers in their sessions, and to invite the authors of those papers to submit to the GSI'23 SI.



Special Issue: GSI23



<https://www.springer.com/journal/41884/editors>

<https://link.springer.com/collections/cadahjefhd>



Frederic Barbaresco and Frank Nielsen

The GSI'23 conference was structured in 25 sessions of 134 papers and 19 posters:

Geometry and Machine Learning

- **Geometric Green Learning**, Alice Barbara TUMPACH, Diarra FALL & Guillaume CHARPIAT
- **Neurogeometry Meets Geometric Deep Learning**, Remco DUITS & Erik BEKKERS, Alessandro SARTI
- **Divergences in Statistics & Machine Learning**, Michel BRONIATOWSKI & Wolfgang STUMMER

Divergences and computational information geometry

- **Computational Information Geometry and Divergences**, Frank NIELSEN & Olivier RIOUL
- **Statistical Manifolds and Hessian information geometry**, Michel NGUIFFO BOYOM

Statistics, Topology and Shape Spaces

- **Statistics, Information and Topology**, Pierre BAUDOT & Grégoire SEARGEANT-PERTHUIS
- **Information Theory and Statistics**, Olivier RIOUL
- **Statistical Shape Analysis and more Non-Euclidean Statistics**, Stephan HUCKEMANN & Xavier PENNEC
- **Probability and Statistics on manifolds**, Cyrus MOSTAJERAN
- **Computing Geometry & Algebraic Statistics**, Eliana DUARTE & Elias TSIGARIDAS

Geometry & Mechanics

- **Geometric and Analytical Aspects of Quantization and Non-Commutative Harmonic Analysis on Lie Groups**, Pierre BIELIAVSKY & Jean-Pierre GAZEAU
- **Deep learning: Methods, Analysis and Applications to Mechanical Systems**, Elena CELLEDONI, James JACKAMAN, Davide MURARI and Brynjulf OWREN

- **Stochastic Geometric Mechanics**, Ana Bela CRUZEIRO & Jean-Claude ZAMBRINI
- **Geometric Mechanics**, Gery DE SAXCE & Zdravko TERZE
- **New trends in Nonholonomic Systems**, Manuel de LEON & Leonardo COLOMBO

Geometry, Learning Dynamics & Thermodynamics

- **Symplectic Structures of Heat & Information Geometry**, Frédéric BARBARESCO & Pierre BIELIAVSKY
- **Geometric Methods in Mechanics and Thermodynamics**, François GAY-BALMAZ & Hiroaki YOSHIMURA
- **Fluid Mechanics and Symmetry**, François GAY-BALMAZ & Cesare TRONCI
- **Learning of Dynamic Processes**, Lyudmila GRIGORYEVA

Quantum Information Geometry

- **The Geometry of Quantum States**, Florio M. CIAGLIA & Fabio DI COSMO
- **Integrable Systems and Information Geometry (From Classical to Quantum)**, Jean-Pierre FRANCOISE, Daisuke TARAMA

Geometry & Biological Structures

- **Neurogeometry**, Alessandro SARTI, Giovanna CITTI & Giovanni PETRI
- **Distance geometry, graph embeddings, and applications**, Antonio MUCHERINO
- **Geometric Features Extraction in Medical Imaging**, Stéphanie JEHAN-BESSON & Patrick CLARYSSE

Geometry & Applications

- **Applied Geometric Learning**, Pierre-Yves LAGRAVE, Santiago VELASCO-FORERO & Teodora PETRISOR

GSI'23 keynote speakers

Eva MIRANDA

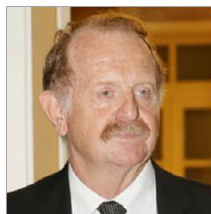
Universitat Politècnica de Catalunya and
Centre de Recerca Matemàtica



**FROM ALAN TURING TO CONTACT
GEOMETRY: TOWARDS A «FLUID
COMPUTER»**

Hervé SABOURIN

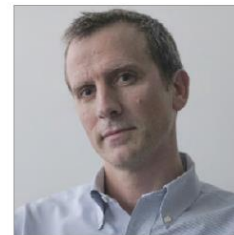
Director for Strategic projects of the Réseau
Figure® (network of 31 universities)
Former Regional Director of the A.U.F
(Agence Universitaire de la Francophonie) for
the Middle East
Former Vice-President of the University of
Poitiers (France)



**TRANSVERSE POISSON
STRUCTURES TO ADJOINT ORBITS
IN A COMPLEX SEMI-SIMPLE LIE
ALGEBRA**

Francis BACH

Inria, Ecole Normale Supérieure



**INFORMATION THEORY WITH
KERNEL METHODS**

Juan-Pablo ORTEGA

Head, Division of Mathematical Sciences.
Associate Chair (Faculty), School of Physical
and Mathematical Sciences. Nanyang
Technological University, Singapore



LEARNING OF DYNAMIC PROCESSES

Diarra FALL

Institut Denis Poisson, UMR CNRS, Université
d'Orléans & Université de Tours, France.



**STATISTICS METHODS FOR
MEDICAL IMAGE PROCESSING AND
RECONSTRUCTION**

Bernd STURMFELS

MPI-MiS Leipzig, Germany



**ALGEBRAIC STATISTICS AND GIBBS
MANIFOLDS**

30th August 09.00



Eva MIRANDA

From Alan Turing to Contact geometry: towards a "Fluid computer"

Is hydrodynamics capable of performing computations? (Moore 1991). Can a mechanical system (including a fluid flow) simulate a universal Turing machine? (Tao, 2016). Etnyre and Ghrist unveiled a mirror between contact geometry and fluid dynamics reflecting Reeb vector fields as Beltrami vector fields. With the aid of this mirror, we can answer in the positive the questions raised by Moore and Tao. This is a recent result that mixes up techniques from Alan Turing with modern Geometry (contact geometry) to construct a "Fluid computer" in dimension 3. This construction shows, in particular, the existence of undecidable fluid paths. I will also explain applications of this mirror to the detection of escape trajectories in Celestial mechanics (for which I'll need to extend the mirror to a singular set up). This mirror allows us to construct a tunnel connecting problems in Celestial mechanics and Fluid Dynamics.

**Polytechnic University
of Catalonia**

30th August 14.00



Poitiers
University

Hervé SABOURIN

Transverse Poisson Structures to adjoint orbits in a complex semi-simple Lie algebra

The notion of transverse Poisson structure has been introduced by Arthur Weinstein stating in his famous splitting theorem that any Poisson Manifold M is, in the neighbourhood of each point m , the product of a symplectic manifold, the symplectic leaf S at m , and a submanifold N which can be endowed with a structure of Poisson manifold of rank 0 at m . N is called a transverse slice at M of S . When M is the dual of a complex Lie algebra \mathfrak{g} equipped with its standard Lie-Poisson structure, we know that the symplectic leaf through x is the coadjoint $G \cdot x$ of the adjoint Lie group G of \mathfrak{g} . Moreover, there is a natural way to describe the transverse slice to the coadjoint orbit and, using a canonical system of linear coordinates (q_1, q_k) , it follows that the coefficients of the transverse Poisson structure are rational in (q_1, q_k) .

31st August 08.30



**Inria
Ecole Normale
Supérieure**

Francis BACH

Information Theory with Kernel Methods

Estimating and computing entropies of probability distributions are key computational tasks throughout data science. In many situations, the underlying distributions are only known through the expectation of some feature vectors, which has led to a series of works within kernel methods. In this talk, I will explore the particular situation where the feature vector is a rank-one positive definite matrix, and show how the associated expectations (a covariance matrix) can be used with information divergences from quantum information theory to draw direct links with the classical notions of Shannon entropies.

31st August 14.45



**Nanyang
Technological
University,
Singapore**

Juan-Pablo ORTEGA

Learning of Dynamic Processes

The last decade has seen the emergence of learning techniques that use the computational power of dynamical systems for information processing. Some of those paradigms are based on architectures that are partially randomly generated and require a relatively cheap training effort, which makes them ideal in many applications. The need for a mathematical understanding of the working principles underlying this approach, collectively known as Reservoir Computing, has led to the construction of new techniques that put together well known results in systems theory and dynamics with others coming from approximation and statistical learning theory. This combination has allowed in recent times to elevate Reservoir Computing to the realm of provable machine learning paradigms and, as we will see in this talk, it also hints at various connections with kernel maps, structure preserving algorithms, and physics inspired learning.

1st September 08.30



Institut Denis Poisson,
UMR CNRS
Université d'Orléans &
Université de Tours,
France

Diarra FALL

Statistics Methods for Medical Image Processing and Reconstruction

In this talk we will see how statistical methods, from the simplest to the most advanced ones, can be used to address various problems in medical image processing and reconstruction for different imaging modalities. Image reconstruction allows to obtain the images in question, while image processing (on the already reconstructed images) aims at extracting some information of interest. We will review several statistical methods (mainly Bayesian) to address various problems of this type.

1st September 14.00



**MPI-MiS, Leipzig,
Germany**

Bernd STURMFELS

Algebraic Statistics and Gibbs Manifolds

Gibbs manifolds are images of affine spaces of symmetric matrices under the exponential map. They arise in applications such as optimization, statistics and quantum physics, where they extend the ubiquitous role of toric geometry. The Gibbs variety is the zero locus of all polynomials that vanish on the Gibbs manifold. This lecture gives an introduction to these objects from the perspective of Algebraic Statistics

Program at glance

Day 1:

Time	Auditorium Maupertius	Room Vauban	Room Bouvet
09.00 - 09.30	Opening Session		
09.30 - 10.30	Eva MIRANDA - (UPC, Spain) From Alan Turing to Contact geometry: towards a "Fluid computer"		
10.30 - 11.00	Coffee Break		
11.00 - 12.40	(5) Neurogeometry Meets Geometric Deep Learning - Remco DUTTS & Erik BEKKERS, Alessandro SARTI	(5) Statistical Manifolds and Hessian information geometry - Michel NGUIFFO BOYOM	(5) Information Theory and Statistics - Olivier RIOUL
12.40 - 14.00	Lunch Break		
14.00 - 15.00	Hervé SABOURIN - (Poitiers Univ., France) Transverse Poisson Structures to adjoint orbits in a complex semi-simple Lie algebra		
15.00 - 16.20	(4/8) Symplectic Structures of Heat & Information Geometry - Frédéric BARBARESCO & Pierre BIELIAVSKY	(4) Applied Geometric Learning - Pierre-Yves LAGRAVE, Santiago VALASCO-FORERO & Teodora PETRISOR	(4) Statistics, Information and Topology - Pierre BAUDOT & Grégoire SEARGEANT-PERTHUIS
16.20 - 16.50	Coffee Break		
16.50 - 18.30	(3/8) Symplectic Structures of Heat & Information Geometry - Frédéric BARBARESCO & Pierre BIELIAVSKY	(5) Distance geometry, graph embeddings, and applications - Antonio MUCHERINO	
19.00 - 20.00	Cocktail		

Day 2:

Time	Auditorium Maupertius	Room Vauban	Room Bouvet
08.30 - 09.30	Keynote Francis BACH - (ENS PARIS & INRIA, France) Information Theory with Kernel Methods		
09.30 - 10.30	(4) Integrable Systems and Information Geometry (From Classical to Quantum) - Jean-Pierre FRANCOISE, Daisuke TARAKA	(4) Divergences in Statistics & Machine Learning - Michel BRONIATOWSKI & Wolfgang STUMMER	(4) Geometric Features Extraction in Medical Imaging - Stéphanie JEHAN-BESSON & Patrick Clarysse
10.30 - 11.20	Coffee Break + GS1'23 Posters Session + CaLIGOLA Posters session - Rita FIORESI		
11.20 - 13.20	(5) Statistical Shape Analysis and more Non-Euclidean Statistics - Stephan HUCKEMANN & Xavier PENNEC	(6) Fluid Mechanics and Symmetry - François GAY-BALMAZ et Cesare TRONCI	(6) Deep learning: Methods, Analysis and Applications to Mechanical Systems - Elena CELEDONI, James JACKAMAN, Davide MURARI and Brynjulf OWREN
13.20 - 14.45	Lunch Break + GS1'23 Posters Session + CaLIGOLA Posters session - Rita FIORESI		
14.45 - 15.45	Juan-Pablo Ortega - (NTU, SG) Learning of Dynamic Processes		
15.45 - 18.05	(6) Computational Information Geometry and Divergences - Frank NIELSEN & Olivier RIOUL	(6) Probability and Statistics on manifolds - Cyrus MOSTAJERAN	(7) Geometric Methods in Mechanics and Thermodynamics - François GAY-BALMAZ et Hiroaki YOSHIMURA
18.05 - 19.00	Coffee Break + GS1'23 Posters Session + CaLIGOLA Posters session - Rita FIORESI		
20.00 - 22.00	Gala Dinner		

Day 3:

Time	Auditorium Maupertius	Room Vauban	Room Bouvet
08.30 - 09.30	Diana FALL - (Orléans Univ., France) Statistics Methods for Medical Image Processing and Reconstruction		
09.30 - 10.50	(4/8) The Geometry of Quantum States - Florio M. CIAGLIA & FABIO DI COSMO	(4/8) Geometric Mechanics - Gery DE SAXCE & Zdravko TERZE	(4/7) Geometric Green Learning - Alice Barbara TUMPAH, Diana FALL & Guillaume CHARPIAT
10.50 - 11.20	Coffee Break		
11.20 - 12.40	(4/8) The Geometry of Quantum States - Florio M. CIAGLIA & FABIO DI COSMO	(4/8) Geometric Mechanics - Gery DE SAXCE & Zdravko TERZE	(3/7) Geometric Green Learning - Alice Barbara TUMPAH, Diana FALL & Guillaume CHARPIAT
12.40 - 14.00	Lunch Break		
14.00 - 15.00	Bernd STURMFELS - (MPI - MS Leipzig, DE) Algebraic Statistics and Gibbs Manifolds		
15.00 - 16.20	(4) Geometric and Analytical Aspects of Quantization and Non-Commutative Harmonic Analysis on Lie Groups - Pierre BIELIAVSKY & Jean-Pierre GAZEAU	(4) Stochastic Geometric Mechanics - Ana Bela CRUZEIRO & Jean-Claude ZAMBRINI	(4) New trends in Nonholonomic Systems - Manuel de LEON & Leonardo COLOMBO
16.20 - 16.50	Coffee Break		
16.50 - 18.30	(5) Learning of Dynamic Processes - Lyudmila GRIGORYEVA	(5) Computing Geometry & Algebraic Statistics - Eliana DUARTE & Elias TSIGARIDAS	(5) Neurogeometry - Alessandro SARTI, Giovanna CITTI and Giovanni Petri
18.30 - 18.45	Closing Session (Papers Awards)		

SESSIONS AUGUST 30TH

	Auditorium Maupertuis	Room Vauban	Room Bouvet
8.00 – 9.00	Welcome desk (badges) and breakfast		
09.00 – 09.30	GSI'23 Opening Session		
09.30 – 10.30	Eva MIRANDA, (UPC, Spain) From Alan Turing to Contact geometry: towards a “Fluid computer”		
10.30 – 11.00	Coffee Break		
11.00 – 12.40	(5) Neurogeometry Meets Geometric Deep Learning, Remco DUITS & Erik BEKKERS, Alessandro SARTI	(5) Statistical Manifolds and Hessian information geometry, Michel NGUIFFO BOYOM	(5) Information Theory and Statistics, Olivier RIOUL
12.40 – 14.00	Lunch Break		
14.00 – 15.00	Hervé SABOURIN, (Poitiers Univ., France) Transverse Poisson Structures to adjoint orbits in a complex semi-simple Lie algebra		
15.00 – 16.20	(4/7) Symplectic Structures of Heat & Information Geometry, Frédéric BARBARESCO & Pierre BIELIAVSKY	(4) Applied Geometric Learning, Pierre-Yves LAGRAVE, Santiago VELASCO-FORERO & Teodora PETRISOR	(4) Statistics, Information and Topology, Pierre BAUDOT & Grégoire SEARGEANT-PERTHUIS
16.20 – 16.50	Coffee Break		
16.50 – 18.30	(3/7) Symplectic Structures of Heat & Information Geometry, Frédéric BARBARESCO & Pierre BIELIAVSKY	(5) Distance geometry, graph embeddings, and applications, Antonio MUCHERIN •	
18.45 – 19.00	Group photo 1		
19.00 – 20.00	Cocktail		

SESSIONS AUGUST 31ST

	Auditorium Maupertuis	Room Vauban	Room Bouvet
08.30 – 09.30	Keynote Francis BACH, (ENS PARIS & INRIA, France) Information Theory with Kernel Methods		
09.30 – 10.50	(4) Integrable Systems and Information Geometry (From Classical to Quantum), Jean-Pierre FRANCOISE, Daisuke TARAMA	(4) Divergences in Statistics & Machine Learning, Michel BRONIATOWSKI & Wolfgang STUMMER	(4) Geometric Features Extraction in Medical Imaging, Stéphanie JEHAN-BESSON & Patrick Clarysse
10.50 – 11.20	Group photo + Coffee Break + GSI'23 Posters Session + CaLIGOLA Posters session, Rita FIORESI		
11.20 – 13.20	(5) Statistical Shape Analysis and more Non-Euclidean Statistics, Stephan HUCKEMANN & Xavier PENNEC	(6) Fluid Mechanics and Symmetry, François GAY-BALMAZ et Cesare TRONCI	(6) Deep learning: Methods, Analysis and Applications to Mechanical Systems, Elena CELLEDONI, James JACKAMAN, Davide MURARI and Brynjulf OWREN
13.20 – 14.45	Lunch Break + GSI'23 Posters Session + CaLIGOLA Posters session, Rita FIORESI		
14.45 – 15.45	Juan-Pablo Ortega, (NTU, SG) Learning of Dynamic Processes		
15.45 – 16.15	Coffee Break + GSI'23 Posters Session + CaLIGOLA Posters session, Rita FIORESI		
16.15 – 18.35	(6) Computational Information Geometry and Divergences, Frank NIELSEN & Olivier RIOUL	(6) Probability and Statistics on manifolds, Cyrus MOSTAJERAN	(7) Geometric Methods in Mechanics and Thermodynamics, François GAY-BALMAZ et Hiroaki YOSHIMURA
18.45 – 19.00	Group photo 2		
20.00 – 22.00	Gala Dinner		

GROUP PHOTO 1

GROUP PHOTO 2

SESSIONS SEPTEMBER 1ST

	Auditorium Maupertuis	Room Vauban	Room Bouvet
08.30 – 09.30	Diarra FALL, (Orléans Univ., France) Statistics Methods for Medical Image Processing and Reconstruction		
09.30 – 10.50	(4/8)The Geometry of Quantum States, Florio M. CIAGLIA & FABIO DI COSMO	(4/8) Geometric Mechanics, Gery DE SAXCE & Zdravko TERZE	(4/7) Geometric Green Learning, Alice Barbara TUMPACH, Diarra FALL & Guillaume CHARPIAT
10.50 – 11.20	Coffee Break		
11.20 – 12.40	(4/8)The Geometry of Quantum States, Florio M. CIAGLIA & FABIO DI COSMO	(4/8) Geometric Mechanics, Gery DE SAXCE & Zdravko TERZE	(3/7) Geometric Green Learning, Alice Barbara TUMPACH, Diarra FALL & Guillaume CHARPIAT
12.40 – 14.00	Lunch Break		
14.00 – 15.00	Bernd STURMFELS, (MPI, MIS Leipzig, DE) Algebraic Statistics and Gibbs Manifolds		
15.00 – 16.20	(4) Geometric and Analytical Aspects of Quantization and Non-Commutative Harmonic Analysis on Lie Groups, Pierre BIELIAVSKY & Jean-Pierre GAZEAU	(4) Stochastic Geometric Mechanics, Ana Bela CRUZEIRO & Jean-Claude ZAMBRINI	(4) New trends in Nonholonomic Systems, Manuel de LEON & Leonardo COLOMBO
16.20 – 16.50	Coffee Break		
16.50 – 18.30	(5) Learning of Dynamic Processes, Lyudmila GRIGORYEVA	(5) Computing Geometry & Algebraic Statistics, Eliana DUARTE & Elias TSIGARIDAS	(5) Neurogeometry Alessandro SARTI, Giovanna CITTI and Giovanni Petri
18.30 – 18:45	Closing Session (Papers Awards)		

GSI'23 Best Paper Award



**The 6th international conference on
Geometric Science of Information**



GSI 2023

August 30th-September 1st 2023
Saint Malo, France

Best Paper Award

PRESENTED TO

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AUTHORS OF THE PAPER

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Thales, France
General co-chair

Frank Nielsen
Sony CSL, Japan
General co-chair

Silvère Bonnabel
Mines Paris PSL, France
Prize committee, President

GEOMSTATS HACKATHON

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?

30th August, 31st August and 1st September (lunch break)

Where?

Vauban Room on the 2nd Floor

Nicolas Guigui and **Luis F. Pereira** 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!

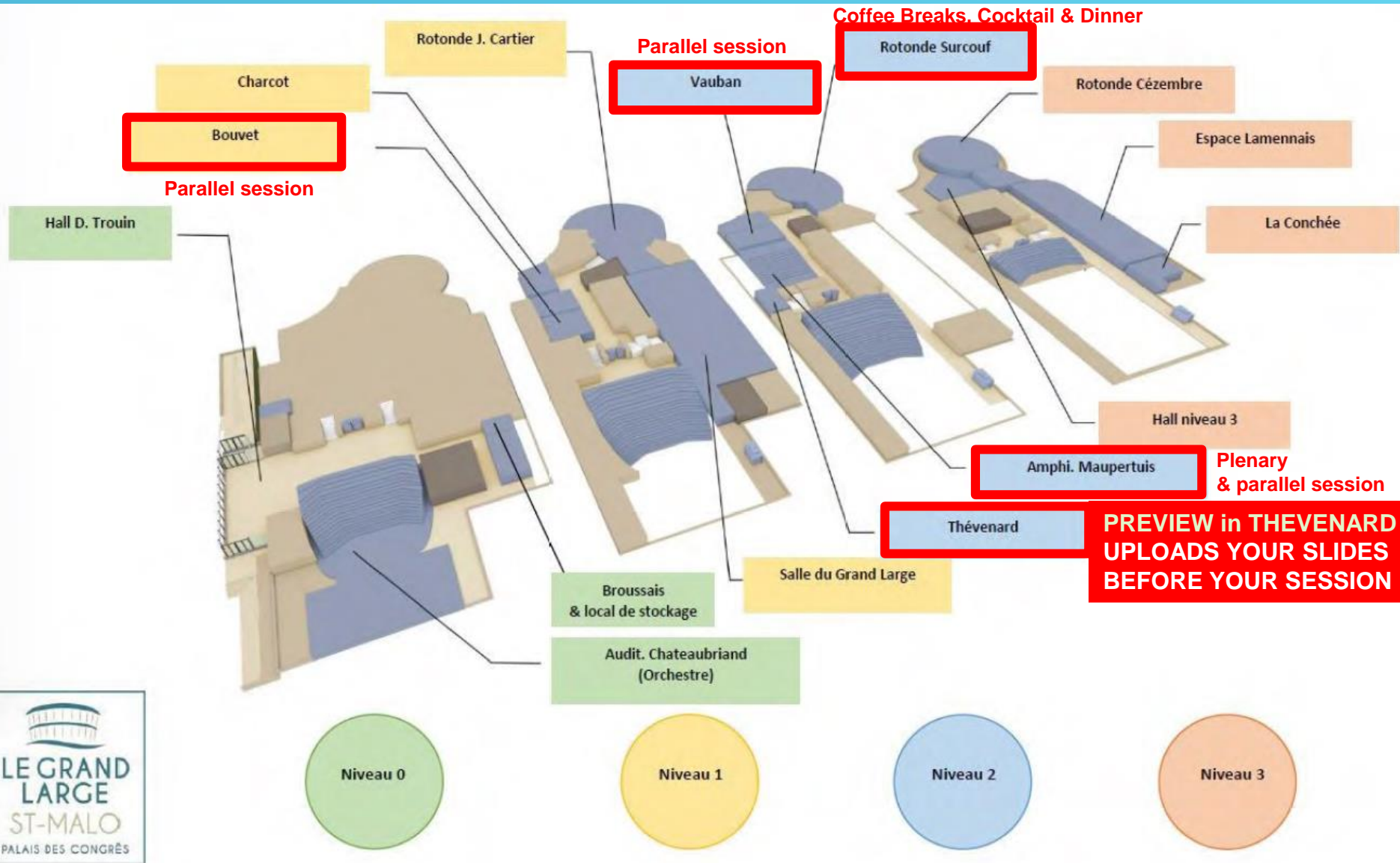
Luis F. Pereira

Yann
Thanwerdas

Elodie Maignant

Nicolas Guigui

Palais du Grand-Large Map





Room Maupertuis (2nd floor)
Plenary Sessions & Parallel Sessions



Room Bouvet (1st floor)
Parallel Sessions



Room Vauban (2nd floor)
Parallel Sessions



Rotonde Surcouf (2nd floor)
Coffee Breaks & Posters Session



Welcome Desk (Ground Floor)
Registration & Badges



ID: **PGL**

Password: **saintmalo**



Welcome Cocktail

The Welcome Cocktail Reception will take place on August 30th at 19.30pm in La Rotonde Surcouf.

Same floor than Maupertuis Plenary Session Room.



Gala Dinner

The Gala Dinner will take place on August 31st at 20.00 pm in La Rotonde Surcouf.

Same floor than Maupertuis Plenary Session Room.

The gala dinner is included in the full registrations only.



List of restaurants

CRÊPERIES

- | | |
|-------------------------|----------------|
| 1 – La Licorne | 02 99 40 05 18 |
| <i>Service continu</i> | |
| 2 – La Brigantine | 02 99 56 82 82 |
| 3 – Le Corps de Garde | 02 99 40 91 46 |
| 4 – Crêperie Des Lutins | 02 99 40 07 29 |
| 5 – Histoire de crêpes | 02 99 40 88 37 |

POISSONS & FRUITS DE MER

- | | |
|------------------------|----------------|
| 6 – Le Café de l'Ouest | 02 99 56 63 49 |
| <i>Service continu</i> | |
| 7 – Ô de Mer | 02 99 40 15 04 |
| 8 – Le Cambusier | 02 99 20 18 42 |
| 9 – Mésion Chalut | 02 99 56 71 58 |

CUISINE TRADITIONNELLE

- | | |
|------------------------|----------------|
| 10 – Le Lion d'Or | 02 99 56 36 02 |
| <i>Service continu</i> | |
| 11 – L'Absinthe | 02 99 40 26 15 |
| 12 – Le Cairn | 02 90 10 17 53 |
| 13 – Fidelis | 02 99 40 97 27 |
| 14 – DOMA | 02 99 40 97 52 |

TAPAS & BRUNCH

- | | |
|-----------------------|----------------|
| 15 – Negroni | 02 99 56 87 73 |
| 16 – Ô Tapas Breton | 02 99 48 19 85 |
| 17 – Récit de Voyages | 02 99 80 66 99 |
| 18 – Bergamote | 02 99 40 97 27 |



We are here

GSI conferences ancestors

Séminaire Léon Brillouin

Sciences géométriques de l'information

2009-2014

<http://repmus.ircam.fr/brillouin/home>

<http://repmus.ircam.fr/brillouin/past-events>

Leon Brillouin Seminar

on

Geometric Science of Information

(Hosted by IRCAM,
Stravinsky Room)

Videos & slides
available online

SÉMINAIRE LÉON BRILLOUIN

SCIENCES GÉOMÉTRIQUES
DE L'INFORMATION

Marc Arnaudon (IMB, Bordeaux)

Un algorithme stochastique pour trouver
les moyennes généralisées
sur les variétés compactes.

14 février 2014
IRCAM - Salle Stravinsky

ÉCOLE
POLYTECHNIQUE

THALES

ircam
Centre
Pompidou

GSI conferences ancestors

INDO-FRENCH

MIG'11 Matrix Information

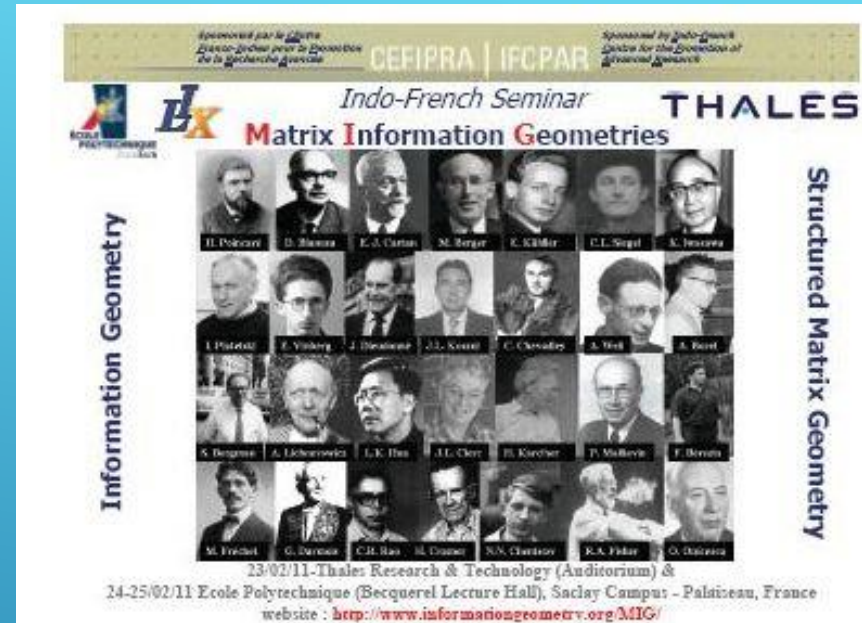
Geometry **Workshop**

(Ecole Polytechnique &
Thales Research & Technology, 2011)

Frank Nielsen · Rajendra Bhatia *Editors*

Matrix
Information
Geometry

 Springer



<https://www.lix.polytechnique.fr/~nielsen/MIG/>

<https://www.lix.polytechnique.fr/~nielsen/MIG/FLYERS-MIG-Final-V2.pdf>

<https://www.lix.polytechnique.fr/~nielsen/MIG/MIG-proceedings.pdf>

THALES



<https://link.springer.com/book/10.1007/978-3-642-30232-9>

GSI biannual conferences

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



GSI'13 Mines ParisTech



GSI'15 Ecole Polytechnique



GSI'17 Mines ParisTech



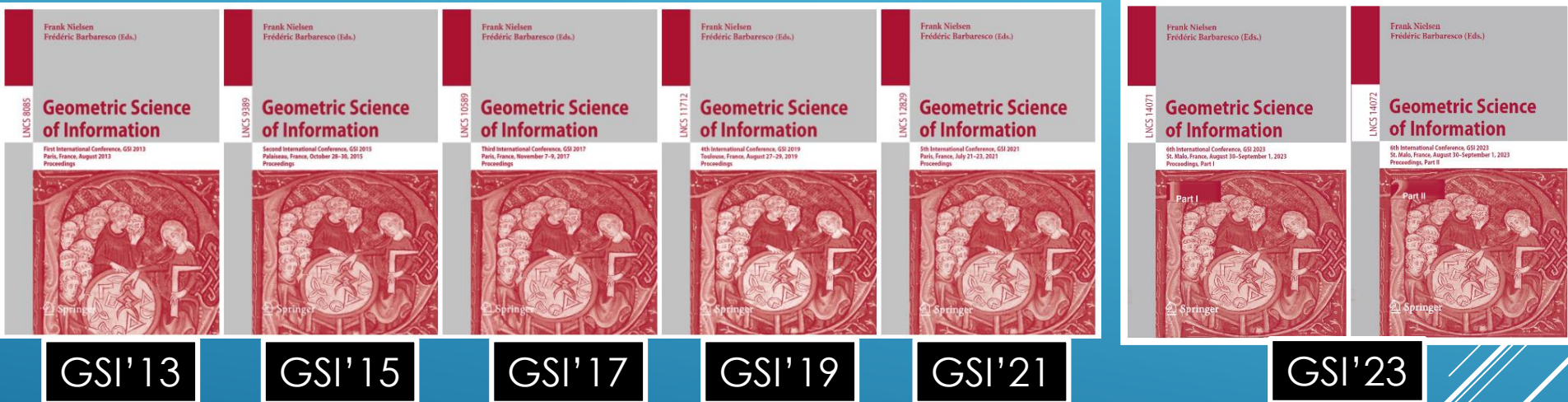
GSI'19 ENAC



GSI'21 Sorbonne University

GSI LNCS Proceedings

About 650 papers in
about 5700 pages



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

Hirohiko Shima
Jean-Louis Koszul



Roger Balian



GSI'13 Mines ParisTech



GSI'15 Polytechnique



Charles-Michel
Marle



Daniel
Bennequin



GSI'17 Mines ParisTech



Jean-Michel Bismut &
Yann Ollivier



GSI'19 ENAC

Gérard
Letac

Elena
Celledoni



GSI'21 Souvenirs



Giuseppe Longo



Yvette
Kosmann-Schwarzbach



Maurice de Gosson

SEE GSI'21 Sorbonne University: videos replays

https://web2.see.asso.fr/wiki/369298_gsi-2021-video-replay-links

Place
de Sorbonne



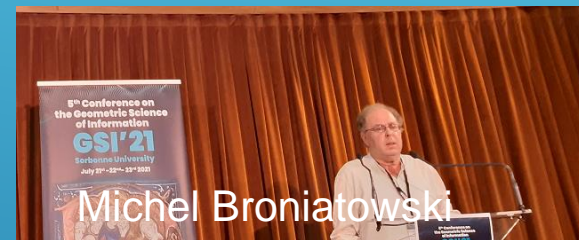
Longo,
Bennequin
& Marle



Gazeau & M & Mme de Gosson



Jean Petitot & Daniel Bennequin



Michel Broniatowski



Max Welling

Other GSI events

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



TGSI'17 CIRM



FGSI'19 IMAG



GRETSI'19 PEYRESQ

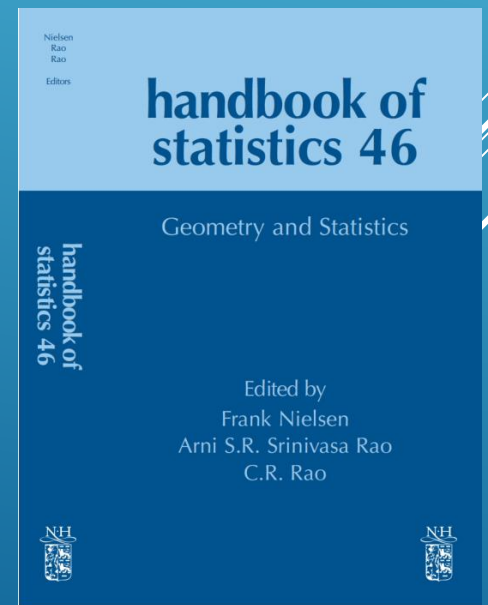
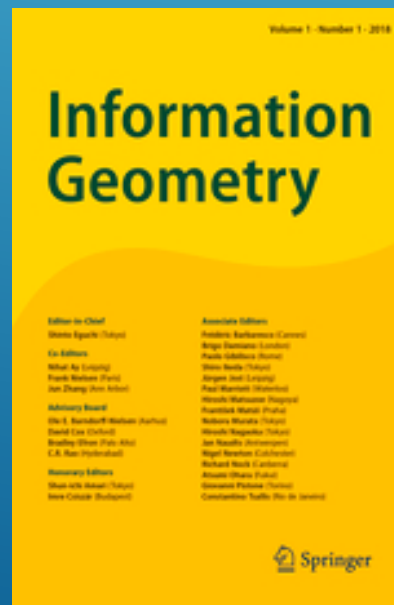
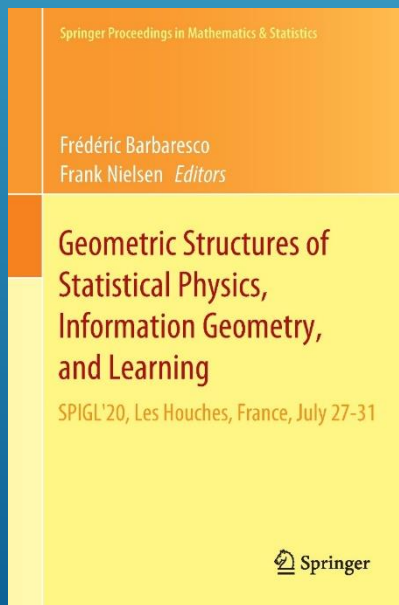
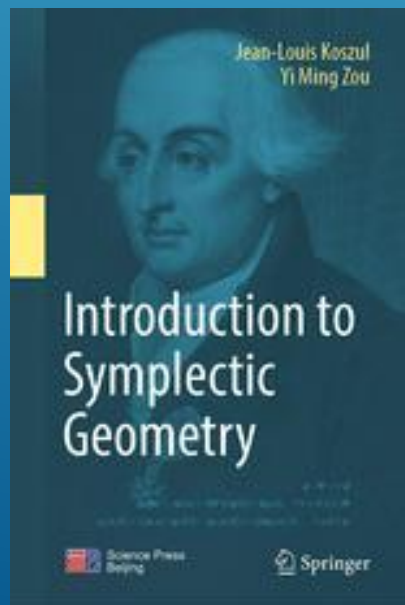
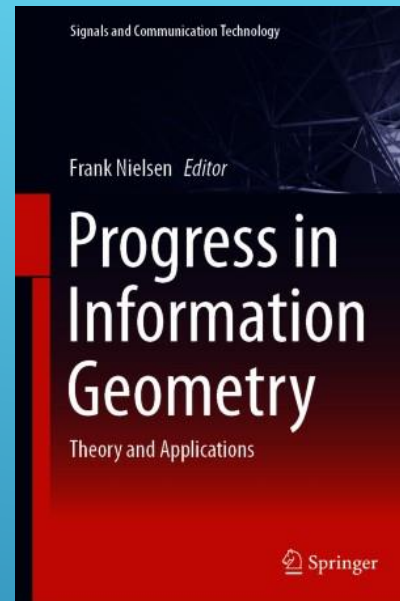
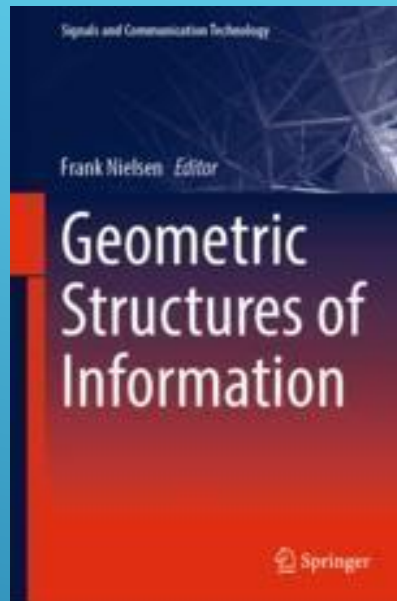
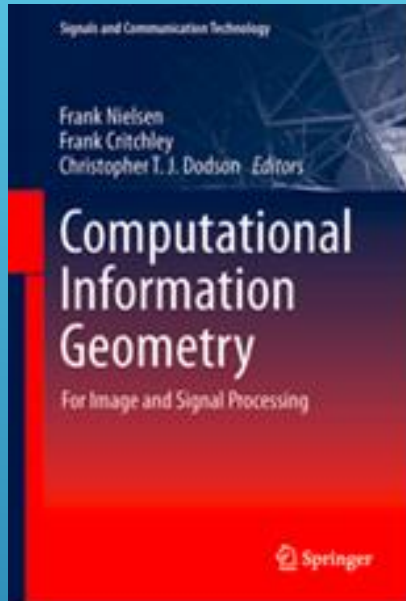


SPIGL'20 LES HOUCHES



MAXENT'22

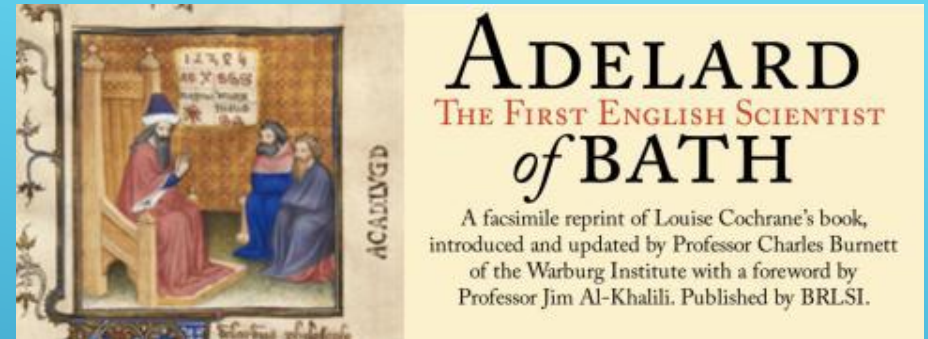
Last Publications



GSI Logo: Adelard of Bath



The frontispiece of an Adelard of Bath Latin translation of Euclid's Elements, c. 1309–1316; the oldest surviving Latin translation of the Elements is a 12th-century translation by Adelard from an Arabic version



- He left England toward the end of the 11th century for **Tours** in France
- Adelard taught for a time at **Laon**, leaving Laon for travel no later than 1109.
- After Laon, he travelled to **Southern Italy** and **Sicily** no later than 1116.
- Adelard also travelled extensively throughout the "lands of the Crusades": **Greece, West Asia, Sicily, Spain, and potentially Palestine.**

Adelard of Bath was the first to translate **Euclid's Elements in Latin**

Adelard of Bath has introduced the word « **Algorismus** » in Latin after his translation of Al Khuwarizmi

GSI MUSIC SIGNAGE JEAN CARTAN

<https://franknielsen.github.io/GSI/sonatina.mp3>



CONCERT JEAN CARTAN

Un concert a eu lieu à la Maison le 22 avril en mémoire de Jean Cartan. Des œuvres d'étudiants de la Maison ont été exécutées et nous donnent le plus grand espoir en ce qui concerne l'avenir musical de ces jeunes gens. L'Introduction pour une fête d'été de Duhamel nous a fait regretter que son sextuor n'ait pu être prêt à temps : nous l'attendons pour le prochain concert, et nous souhaitons que son talent s'affermisse sans pour cela perdre cette fraîcheur qui a fait la joie de tous les auditeurs. Nous connaissons jusqu'ici Guy Lefranc comme violoniste ; nous avons bien aimé ses accompagnements de poèmes et devant le succès de ses pièces pour piano, nous ne pouvons que l'encourager à écrire les œuvres pour les jouer ultérieurement. Une mention toute particulière à Jean Paidassi pour ses mélodies dont la forme romantique contrastait avec celle des œuvres de ses camarades. Son talent robuste la fermeté de son écriture musicale, la richesse mélodique de ses thèmes nous ont fait regretter qu'il n'ait pu nous donner davantage.



Jean Cartan

Outre ces œuvres de débutants, le concert comprenait une partie consacrée à Jean Cartan, dont le frère, M. Henri Cartan, nous a fait admirer d'abord l'**Hommage à Dante**, pièce pour piano empreinte d'une noble grandeur et exécutée par des mains expertes et pieuses. Mme Noémie Perugia nous avait fait l'honneur et le plaisir de venir chanter quelques-unes de ces mélodies qu'elle aime et qui sont toutes remplies de tendresse et de douceur ; la salle l'en remercia chaleureusement par des applaudissements répétés. Enfin un quatuor de la Maison des Sciences formé par Jean Augé (1^{er} violon), de Guy Lefranc (2^e violon), de Mme Barbier (alto) et de Monique Pérone (violoncelliste) exécuta le **Premier quatuor** de Jean Cartan. La beauté des thèmes mélodiques, la science du contrepoint, la richesse harmonique, la plénitude de la pensée musicale, tout concourt à faire de cette pièce un chef-d'œuvre, parmi les meilleurs. Nous souhaitons vivement pouvoir en d'autres occasions faire connaître à nos étudiants et au public universitaire d'autres œuvres de ce jeune compositeur trop tôt disparu. Nous remercions très vivement Henri Cartan qui a bien voulu nous prêter les textes et diriger les répétitions. L'exécution très difficile de l'œuvre a mis en valeur le talent de cette jeune équipe que nous espérons entendre à nouveau.

Nous voulons en terminant assurer de notre reconnaissance les personnalités qui ont bien voulu venir encourager de leur présence nos étudiants, en particulier M. le professeur Elie Cartan, M. Georges Bruhat directeur adjoint de l'Ecole Normale Supérieure, M. Friedel, directeur de l'Ecole des Mines, M. le professeur Garnier, M. le professeur Kastler, M. Bourcart, maître d'éducation générale de la Faculté des Sciences.

Nous signalons aux amis de la Maison que des **Œuvres poétiques** d'étudiants seront lues et récitées à la Maison le samedi 21 mai et qu'un **Récital Cortot** aura lieu le 8 mai à 18 heures.



JEAN CARTAN, brother of Henri Cartan and son of Elie Cartan. Jean Cartan was a pupil of Albert Roussel, who was himself a pupil of Julien Koszul (the grandfather of the mathematician Jean-Louis Koszul). On April 22, 1944 concert at the House of Parisian students in tribute to Jean Cartan. Henri Cartan plays "L'homage à Dante" on the piano, which is followed by "Le 1er quatuor" by Jean Cartan played by a young ensemble. It was Henri Cartan who conducted the rehearsals. We note in the audience the presence of Elie Cartan and Georges Bruhat. In July 1931, the Sonatine for flute and clarinet, "the twin brother of Poulenc's Sonata for two clarinets", was warmly applauded at the festival of the International Society for Contemporary Music in Oxford. Jean Cartan died the following year on March 26, 1932 at the age of 26. **The Sonatine for flute and clarinet by Jean Cartan is the official music of the SEE GSI conference "Geometric Science of Information" ;**

Sonatine pour flûte et clarinette: <https://www.youtube.com/watch?v=4-J7zdYtu3Q>

Introduction et Allegro:: <https://www.youtube.com/watch?v=xeiF4JgsPuA>

Albert ROUSSEL, « Jean Cartan », Revue Musicale, no 126 (mai 1932)

Jean Cartan ou le génie décapité (Elie Cartan's son)

INTRODUCTION & ALLEGRO by JEAN CARTAN

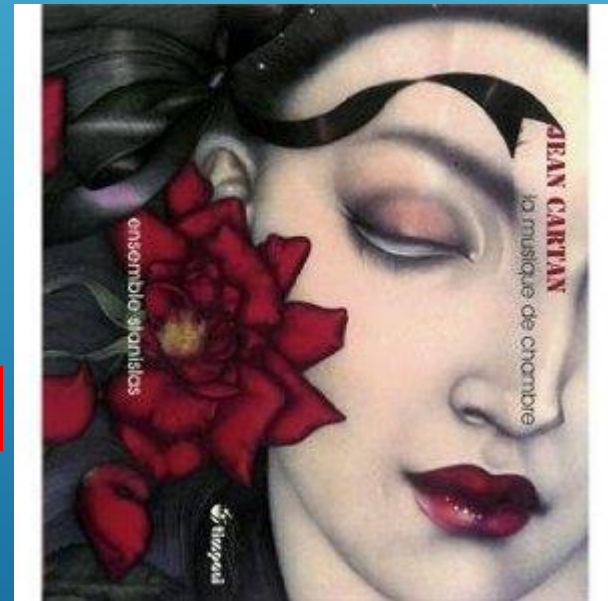
<https://www.see.asso.fr/en/node/24148>

Chronologically, Jean Cartan composed between 1926 and 1930 the Introduction and Allegro for flute, oboe, clarinet, horn, bassoon and piano (the same training as Roussel's Op.6, his mentor who will follow his whole career not without his 'influence'), the Quartet No. 1 (1927) dedicated precisely to Roussel, the Quartet No. 2 (1930) and finally the Sonatine for flute and clarinet (1931).

<https://www.resmusica.com/2011/10/14/jean-cartan-ou-le-genie-decapite/>

Julien Koszul => Albert Roussel => Jean Cartan

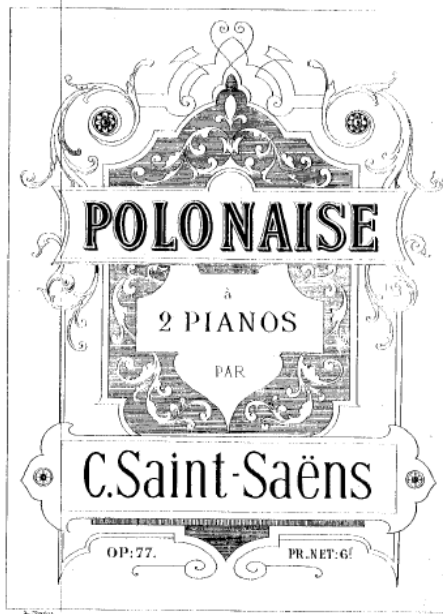
Albert Roussel studied harmony in Roubaix with **Julien Koszul**.
Condisciple of **Olivier Messiaen** and **Maurice Duruflé**, the career of **Jean Cartan** is followed attentively by **Albert Roussel**.



JULIEN KOSZUL: MOMENT 1900 & ECOLE NIEDERMAYER

- **Julien KOSZUL (1844-1927):**
Grandfather of Jean-Louis Koszul and composer Henri Dutilleux, student of Camille Saint-Saëns and friend of Gabriel Fauré. Professor of Albert Roussel.

A Monsieur Julien KOSZUL.

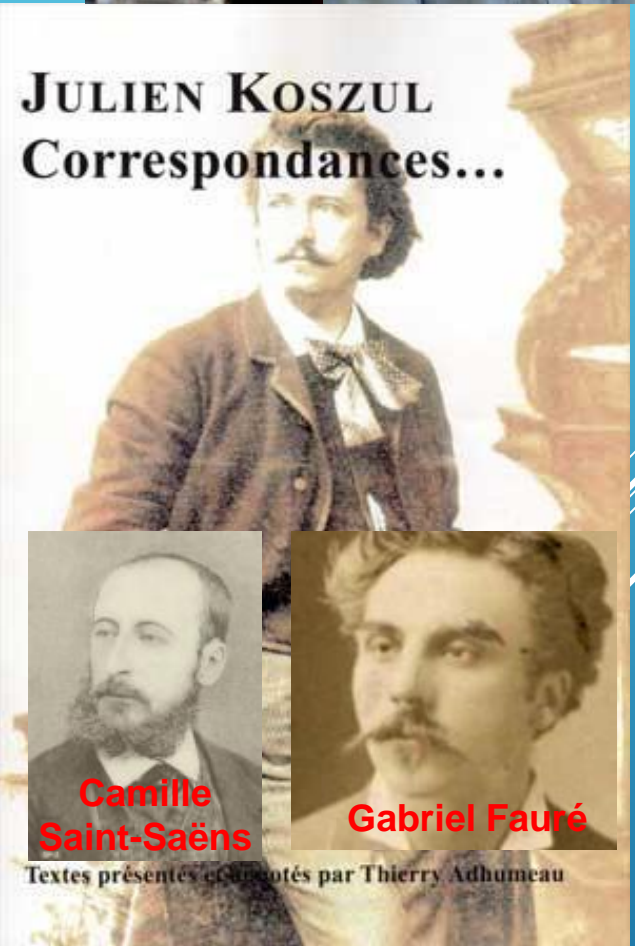


Henri
Dutilleux



Jean-Louis
Koszul

JULIEN KOSZUL Correspondances...



Camille
Saint-Saëns

Gabriel Fauré

Textes présentés et annotés par Thierry Adhumeau

G. Fauré à Julien Koszul¹

Rue des Vignes 32 XVI^e 21 avril 1924

Mon cher ami

Je te remercie de m'avoir envoyé une jolie Berceuse qui me donne le vif désir de connaître les autres mélodies ; je les demanderai à Hamelle.

Es-tu content de ta santé ? Ne viens-tu jamais à Paris ? Je serais tellement heureux de te revoir, de pouvoir bavarder un peu longuement avec toi ! Nous avons tant de bons souvenirs. Te souviens-tu que c'est toi qui introduisais *Schumann* à l'École Niedermeyer où il était si profondément inconnu et où n'avons pas tardé, tous, à l'adorer ?

Et puis, autres moins lointains souvenirs, mes visites à Roubaix et l'accueil délicieux que je recevais dans ta chère maison !

Donne-moi de tes nouvelles ; parle-moi de tes enfants, et, si tu as une photo, envoie-la moi comme je t'envoie la mienne². J'y joins, mon cher ami, toute ma vieille et bien fidèle amitié

Gabriel Fauré

Bibliothèque nationale, département de la Musique, don d'Henri Dutilleux

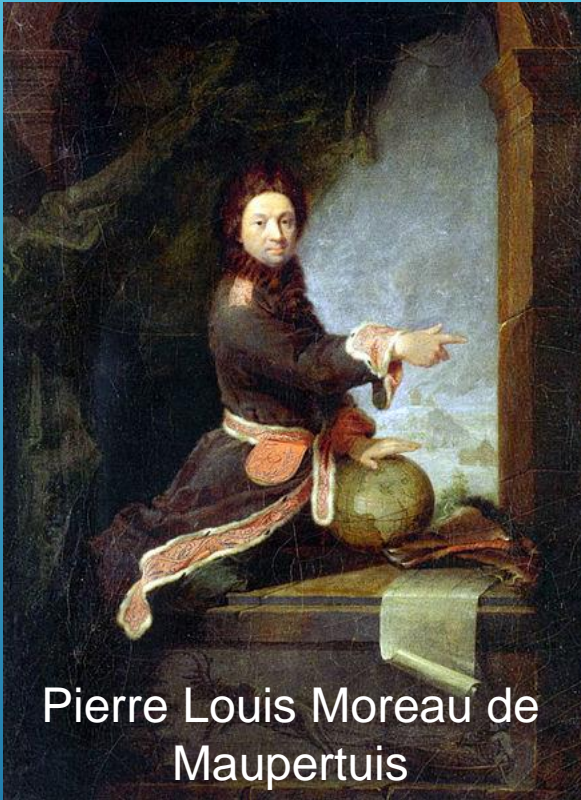


Julien Koszul

¹. Voir plus haut la lettre que lui adressa le jeune Fauré en juin 1870 (lettre 7). Enveloppe portant le cachet postal Paris, 22.IV.1924 : « Monsieur J. Koszul, Ancien Directeur du Conservatoire de Roubaix, Douai. Nord »

². Photo jointe : portrait de Fauré en 1924 par les frères Manuel.

Pierre Louis Moreau de Maupertuis, King's Musketeer Lieutenant of Science and Son of Saint-Malo Corsaire



Pierre Louis Moreau de
Maupertuis



French surveyor and mathematician, working to
measure the terrestrial meridian in Lapland

The rejection of the Newtonian approach, as well as the distrust of the Cartesian approach, lead Maupertuis to the elaboration of a cosmology different from both the finalism of some and the anti-finalism of others. It is a cosmology that cannot be attributed to any particular tradition, and that must rather be read as an independent and creative elaboration. All of Maupertuis' cosmology is based on a physical principle which he was the first to formulate, namely **the principle of least action**, the novelty of which he underlines on several occasions and generality.

MAUPERTUIS'S **PRINCIPLE OF LEAST ACTION**

« *La lumière ne pouvant aller tout-à-la fois par le chemin le plus court, et par celui du temps le plus prompt ... ne suit-elle aucun des deux, elle prend une route qui a un avantage plus réel : le chemin qu'elle tient est celui par lequel la quantité d'action est la moindre.* » [**Since light cannot go both by the shortest path and by that of the quickest time... if it does not follow either of the two, it takes a route which has a more real advantage: the path that it holds is that by which the quantity of action is least.**] - Maupertuis 1744

Maupertuis's principle was renewed by **Cartan-Poincaré Integral Invariant** in the field of geometric mechanics. The integral invariant is defined as the integral of the symplectic form over a closed loop in the configuration manifold.

More recently, Maupertuis's principle has been extended by **Jean-Marie Souriau** through **Maxwell's principle** with the hypothesis that the exterior derivative of the Lagrange 2-form of a general dynamical system vanishes. For the systems of material points, Maxwell's principle allows, under certain conditions, to define a Lagrangian and to show that the **Lagrange form is nothing else than the exterior derivative of the Cartan form**, in the study of calculus of variations.

Jean-Marie Souriau declares that **Maupertuis's principle and least action principle seem to him less fundamental than Maxwell's principle**. His viewpoint seems to him justified because the existence of a Lagrangian is ensured only locally, and because there exist important systems, such as those made of particles with spin, to which Maxwell's principle applies while they have not a globally defined Lagrangian.

BLAISE PASCAL 400TH BIRTHDAY

« ALEAE 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

Blaise Pascal and DUALITY

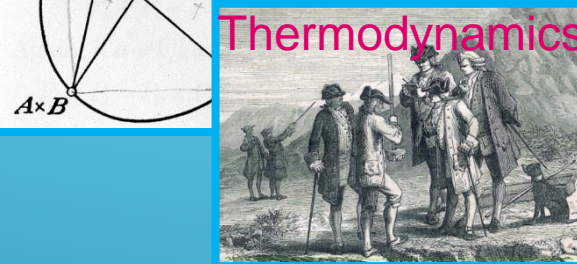
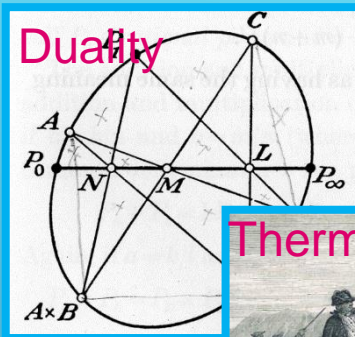
Pascal's **Hexagrammum Mysticum Theorem**, and its dual **Brianchon's Theorem**. In 1639 Blaise Pascal discovered, at age sixteen, the famous hexagon theorem, also developed in "Essay pour les Coniques", printed in 1640, declaring his intention of writing a treatise on conics in which he would derive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



Pascaline

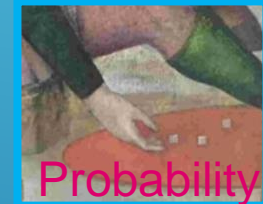
Blaise Pascal and COMPUTER

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



Probability

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.



Blaise Pascal

ALEAE GEOMETRIA

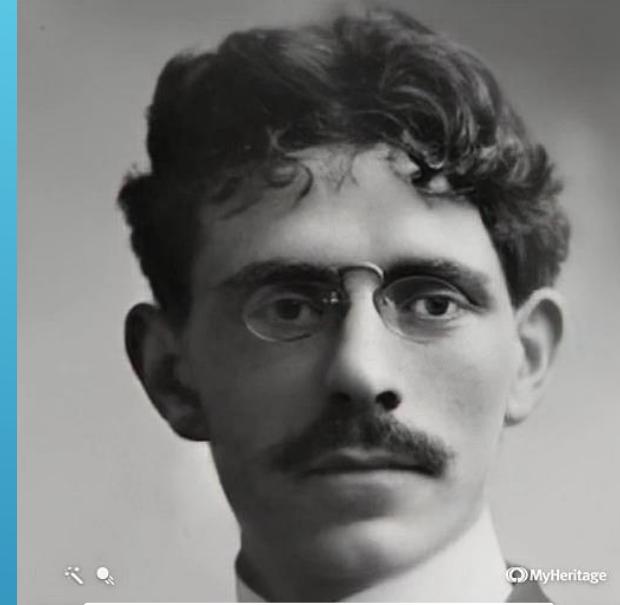
FRENCH CONTRIBUTORS TO GEOMETRIC SCIENCE OF INFORMATION



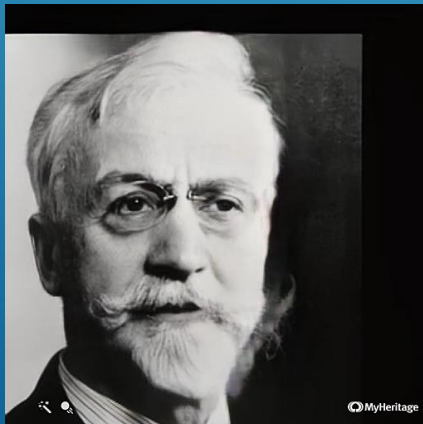
Jean-Marie Souriau (ENS 1942)



Jean-Louis Koszul (ENS 1940)



Maurice Fréchet (ENS 1903)



Elie Cartan



Henri Poincaré

FRENCH CONTRIBUTORS TO CALCULUS OF VARIATIONS

Pierre
de Fermat



Fermat's principle
of least time

Pierre
Louis
Maupertuis



Maupertuis's
principle of
least action

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

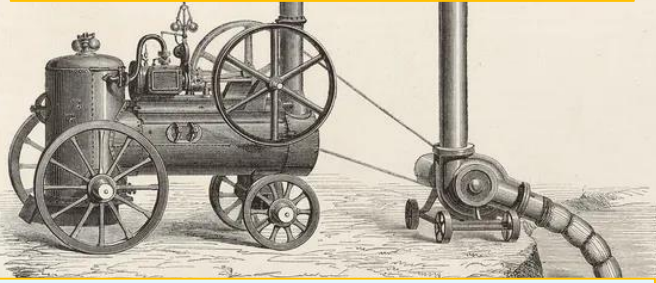
Jean-Michel
Bismut



Random
Mechanics

FRENCH CONTRIBUTORS TO THERMODYNAMICS

Steam Engine Revolution



Classical Thermodynamics

GAY-LUSSAC

CLAPEYRON

CARNOT

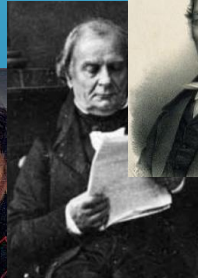
FOURIER

BIOT

LAVOISIER

PAPIN

PASCAL



MASSIEU



DUHEM

BRILLOUIN



BALIAN



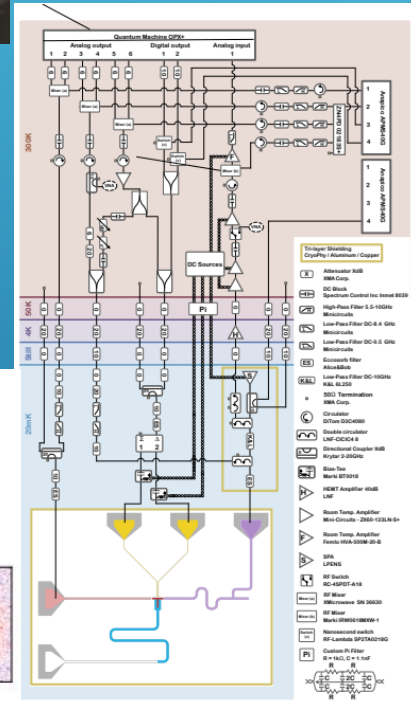
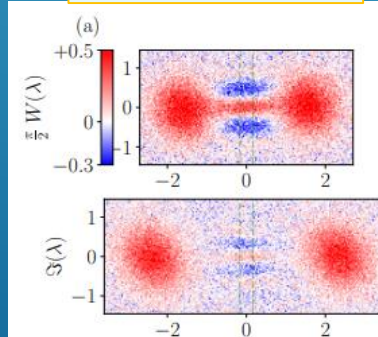
SOURIAU



ROUCHON



Quantum Computing Revolution



Quantum Thermodynamics

FRANÇOIS MASSIEU POTENTIALS (1869)



Massieu

Robert Delandin

Engineer from CORPS
DES MINES, Professor at
Rennes University

MÉMOIRES

PRÉSENTÉS PAR DIVERS SAVANTS

A L'ACADÉMIE DES SCIENCES

DE L'INSTITUT NATIONAL DE FRANCE.

TOME XXII. — N° 2.

THERMODYNAMIQUE.

MÉMOIRE

SUR

LES FONCTIONS CARACTÉRISTIQUES DES DIVERS FLUIDES
ET SUR LA THÉORIE DES VAPEURS,

PAR F. MASSIEU,

INGÉNIEUR DES MINES, PROFESSEUR À LA FACULTÉ DES SCIENCES DE RENNES.

MÉMOIRES PRÉSENTÉS.

THERMODYNAMIQUE. — *Addition au précédent Mémoire sur les fonctions caractéristiques. Note de M. F. MASSIEU, présentée par M. Combes.*

» Cette conclusion résultait *a posteriori* de la théorie même; mais j'ai reconnu qu'il était possible de l'établir de prime abord par un procédé qui a l'avantage de conduire plus simplement à la connaissance de la fonction caractéristique et de montrer la liaison de cette fonction avec d'autres fonctions déjà introduites dans la science, savoir : l'entropie S et l'énergie ou chaleur interne U . Je rappellerai d'ailleurs qu'une fois la fonction caractéristique d'un corps déterminée, la théorie thermodynamique de ce corps est faite.

$$\phi = S - \frac{U}{T}.$$

Or, pour avoir S et U , et par suite ϕ , il suffit de connaître quelles sont les quantités élémentaires de chaleur dQ qu'il faut fournir au corps suivant un cycle quelconque, pour le faire passer d'un état initial à un état déterminé, et en outre l'accroissement dU de sa chaleur interne pour les différents éléments de ce cycle, ou de tout autre cycle, reliant le même état initial au même état final.

FRANÇOIS MASSIEU & THERMODYNAMICS POTENTIALS

François Massieu and the thermodynamic potentials - Roger Balian

- **Abstract:** The thermodynamic potentials have first been introduced in 1869 by François Massieu under the name of “fonctions caractéristiques” in two short articles published in the Comptes rendus de l'Académie des sciences. Motivated by applications to thermal engines, he showed how such a single function encompasses all properties of a fluid, linking its equation of state to its thermal properties. The conceptual interest of Massieu's functions was acknowledged many decades later.



INSTITUT DE FRANCE
Académie des sciences

Histoire des sciences / Évolution des disciplines et histoire des découvertes – Avril 2015

François Massieu et les potentiels thermodynamiques

par Roger Balian, membre de l'Académie des sciences

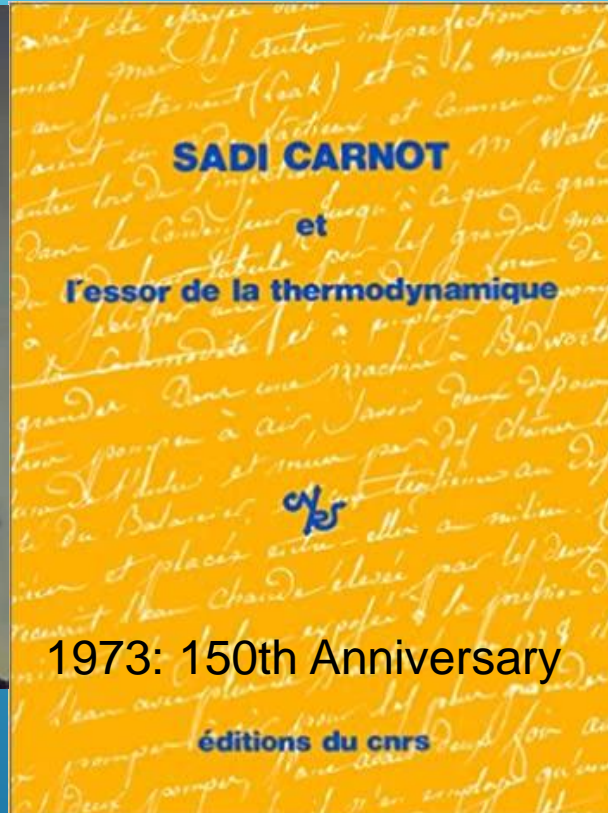
Tables des matières

1. Qu'est-ce qu'un potentiel thermodynamique ?
2. François Massieu : de Vatteville à Rennes
3. Les fonctions caractéristiques de Massieu
4. De Rennes à Paris

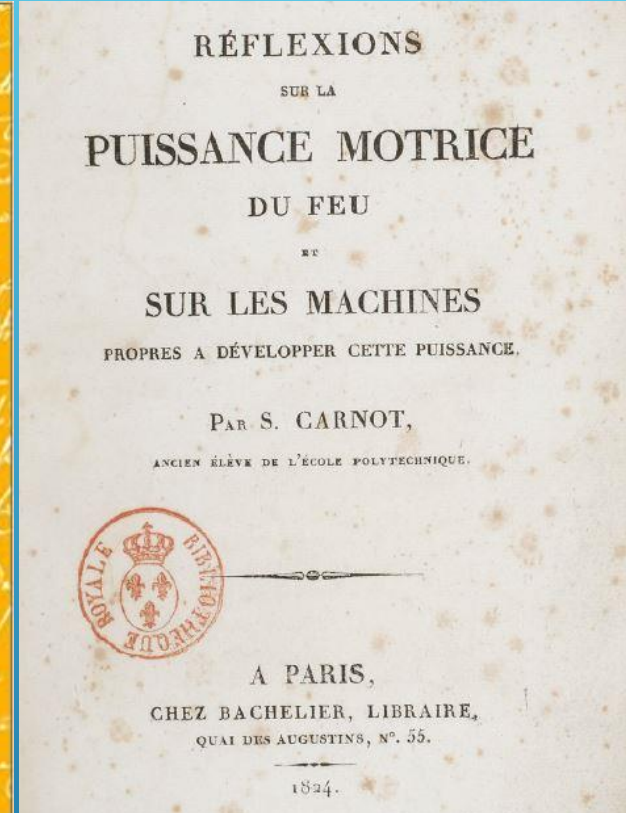
3. Les fonctions caractéristiques de Massieu

C'est en 1869 que fut publiée en quelques pages³ l'œuvre majeure de François Massieu, où il introduisit sous le nom de « fonctions caractéristiques » la notion de potentiels thermodynamiques. A la fois ingénieur et physicien, Massieu était comme Sadi Carnot motivé par les applications de la science aux machines à vapeur. Optimiser le fonctionnement de celles-ci suppose une maîtrise des propriétés de la vapeur d'eau, qui ne sont pas faciles à mesurer dans les conditions de fonctionnement des machines, notamment lorsque la vapeur est surchauffée ; les renseignements théoriques sont donc précieux. En pratique, on a besoin de connaître aussi bien l'équation d'état du fluide que ses comportements calorifiques. Or, si ces propriétés sont susceptibles de découler d'un seul et même potentiel thermodynamique, elles ne sont pas indépendantes. Il était donc essentiel de reconnaître ce fait, qui permet de relier des phénomènes différents ; on peut ainsi en particulier déduire à partir de données sûres des grandeurs expérimentalement peu accessibles. Massieu se lança aussi dans cette direction parce qu'il estimait que le rôle de la théorie était d'établir des liens entre faits d'observation, et parce qu'il souhaitait synthétiser les principes de la thermodynamique. Dès sa découverte des fonctions caractéristiques et sans avoir besoin de déterminer leur forme précise, il tira de leur simple existence des relations qui permirent en particulier de prouver l'incohérence de certains travaux existants.

SADI CARNOT BOOK: 200TH BIRTHDAY OF THERMODYNAMICS (1824-2024)



1973: 150th Anniversary



1st & 2nd Thermodynamics Principles

1824-2024: 200 years
publication of Carnot's Book



carnotlille2024

Celebration of 200 years since Sadi Carnot's
Réflexions sur la puissance motrice du Feu, 1824–2024

11-13 September 2024 Lille/Villeneuve d'Ascq, France

© DRONEPIER / Altstadt Lille Panorama



LÉONARD SADI

CARNOT

PARIS 1^{ER} JUIN 1796

TVRY 24 AOUT 1832

ELÈVE DE L'ÉCOLE POLYTECHNIQUE

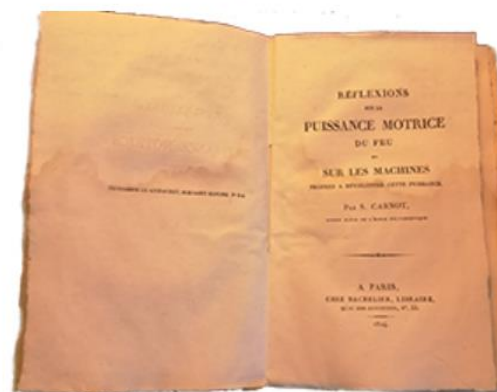
CAPITAINE DU GÉNIE

PHYSICIEN

FONDATEUR DE LA

THERMO DYNAMIQUE

International Colloquium Carnot 1824-2024



Raffaele Pisano Received it as Kind Present by M. Thierry & Mme Caroline Carnot, direct descendants' Carnot Family

The book is one of the original 600 copies published by Sadi Carnot in 1824, as archived at Carnot's Family Chateau de Presles, Paris

Celebration of 200 years since Sadi Carnot's *Réflexions sur la puissance motrice du Feu*, 1824–2024 & les Carnots

Hosted by History of Physics and Applied Science & Technologies Team (HOPAST) at IEMN, France

Patronage by French Académie des Sciences

11-13 September 2024, LILLIAD, University of Lille, France

Official Website URL: www.carnotlille2024.com

Announcement: Maurice Fréchet 50th years anniversary of death

https://perso.lpsm.paris/~mazliak/programme_ang.html



Welcome

Scientific Committee

Program

General information

Inscription (free but
mandatory)



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M

aurice Fréchet: Mathematics, the abstract and the concrete

International conference

Institut Henri Poincaré, Paris

9-11 October 2023

The year 2023 marks the 50th anniversary of the death of Maurice Fréchet (1878-1973) and the present conference is the first to be organized about this hyper-active character who was one of the most influential French scientists of the 20th century. The author of major discoveries in analysis, notably in topology and integration theory, Fréchet was also a pioneer of modern probability and statistics to which he made fundamental contributions. He was also a great organizer of the mathematical life of his time, in particular at the University of Strasbourg after 1919 and then in Paris, at the Institut Henri Poincaré, where Borel installed him as a project leader from the opening in 1928. But Fréchet was also concerned with other aspects of intellectual life: important epistemological reflections, a leading role in the setting up of new institutions (the CNRS, the AFNOR, etc.) and also a very strong commitment to the development of Esperanto, of which he was a passionate promoter. In addition to all this, he was a polyglot traveller who travelled the world for six decades and created an impressive network around him. This three-day conference will attempt to present different elements of this rich life and abundant production.

Organization : Frédéric Jaëck (Aix-Marseille) and Laurent Mazliak (Sorbonne-Université, Paris)

Announcement: René Thom 100th Birthday

1923-2023 CENTENAIRE DE RENÉ THOM

IHES 20-21-22 SEPTEMBRE 2023

Centre de conférences Marilyn et James Simons
35 route de Chartres, 91440 Bures-sur-Yvette

Conférenciers

Norbert A'Campo, *Univ. de Bâle*
Daniel Bennequin, *IMJ-PRG*
Alain Chenciner, *IMJ-PRG*
Antoine Danchin, *Institut Pasteur*
Ivar Ekeland, *Univ. Paris-Dauphine*
Sara Franceschelli, *ENS Lyon*
Emmanuel Giroux, *ENS Lyon*
Misha Gromov, *IHES*
Krzysztof Kurdyka, *Univ. Savoie Mont Blanc*
Cherif Matta, *Mount Saint Vincent Univ. Halifax*
Jean Petitot, *EHESS*
Oscar Randal-Williams, *Univ. de Cambridge*
Ana Rechtman, *Univ. de Strasbourg*
Dennis Sullivan, *CUNY Graduate Center*
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Marc Chaperon, *IMJ-PRG*, Antoine Danchin, *Institut Pasteur*,
Yakov Ellashberg, *Stanford Univ.*, Maxim Kontsevich, *IHES*,
Cédric Villani, *Univ. Lyon 1* & *IHES*

Comité d'organisation : Jean-Pierre Bourguignon, *IHES*



ACADÉMIE
DES SCIENCES
INSTITUT DE FRANCE

Colloque

Grande salle des séances
Institut de France

23 QUAI DE CONTI - 75006 PARIS

MARDI 19 SEPTEMBRE 2023 - DE 14H30 À 17H30

L'HÉRITAGE DE RENÉ THOM, GÉOMÈTRE PAR EXCELLENCE



Information et inscription : www.ihes.fr

L'IHES, membre-fondateur de
université
PARIS-SACLAY

Institut de recherches
Mathématiques
d'Oberwolfach, 1949



René THOM

Jean-Pierre SERRE

Georges REEB

“We haven't yet discovered **the foliations**, but it will come. I am convinced that the fundamental problem posed by **quantum mechanics** is the following problem. ... it will be necessary to take into consideration **more complicated mathematical structures, such as foliations** ... It's a bit my hope that one day or another, we will manage to develop models where a **phenomenon will be defined as a leaf of foliation** in a product of spaces of vision by a space of observer positions.” – René Thom in “DETERMINISME ET INNOVATIONS”
<https://www.youtube.com/watch?v=BXxKQVQFnRo>

“At the start, the theory of structural stability had seemed to me of such breadth and generality, that with it I could hope in some way **to replace thermodynamics by geometry, to geometrize in a certain sense thermodynamics**, eliminate from thermodynamic considerations all aspects of a measurable and stochastic nature to retain only the corresponding geometric characterization of the attractors.” – René Thom

ENJOY GSI'23



« 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



ENJOY SAINT-MALO & FRENCH BRITTANY



Saint-Malo



Dinard



Mont Saint-Michel

SAINT-MALO TIDES: HIGHEST IN EUROPE

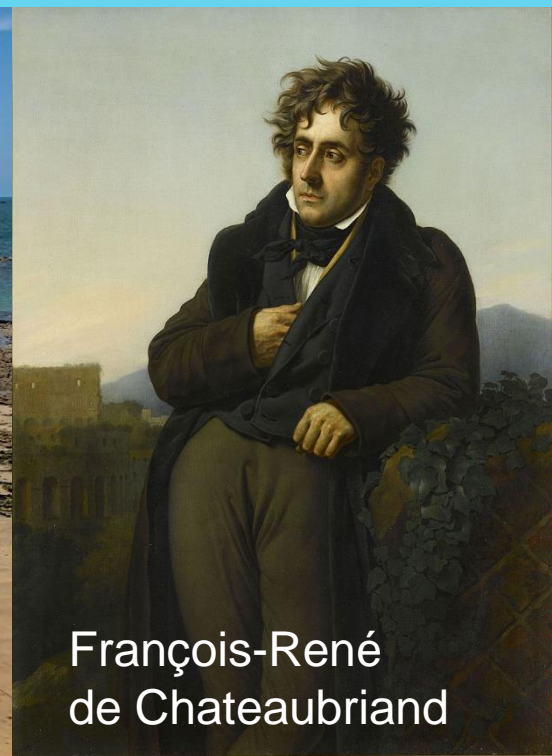


Saint-Malo has highest tides in Europe, and during GSI'23, we will have highest 2023 Saint-Malo tides of the year with a **tide coefficient of 112 (13,33 meters of marling)**.

You will attend the 1st lodges for these highest tides of the year from the “Palais du Grand Large” GSI'23 conference center. For people staying during the week-end, they could see highest 2023 tides at Mont-Saint-Michel (45 minutes from Saint-Malo) or visit Dinard (just in front of Saint-Malo) and French Brittany Emeraude coast.

Chateaubriand's Tomb at Saint-Malo

(Born in Saint-Malo on 4 September 1768, the last of ten children, Chateaubriand grew up at his family's castle "the château de Combourg" in Brittany): Birth of Romanticism in Chateaubriand's *Mémoires d'outre-tombe*



François-René
de Chateaubriand



Saint-Malo Museum



Jean-Baptiste CHARCOT
(Polar Explorer)

6th International Conference on
**GEOMETRIC SCIENCE
OF INFORMATION**

GSI'23

Saint-Malo, France

30th August to 1st September 2023