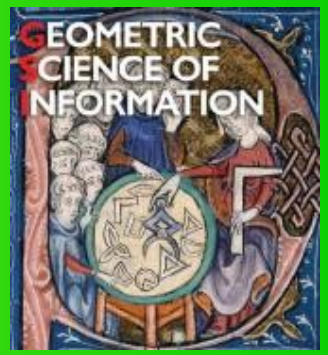
Société de l'électricité, de l'électronique et des technologies de l'information et de la communication



Geometric Science of Information

GSI'15

Frédéric BARBARESCO* & Frank Nielsen**

GSI'15 General Chairmen

(*) President of SEE SI²D Club (Signal, Image, Information & Decision)

(**) LIX Department, Ecole Polytechnique

Flash-back

GSI'13 Ecole des Mines de Paris

Hirohiko Shima
Jean-Louis Koszul
Shin-Ichi Amari

SEE at a glance

http://www.see.asso.fr/

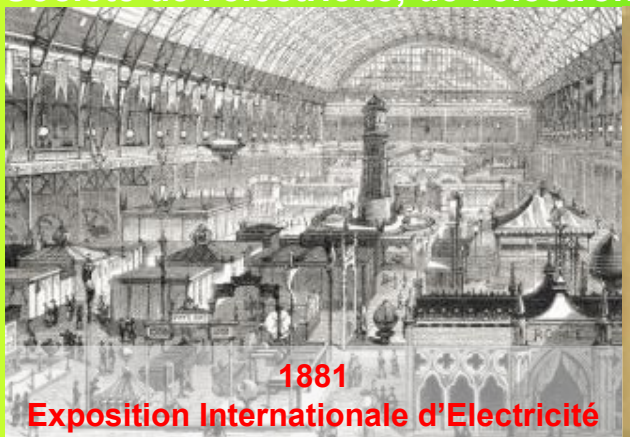
- Meeting place for science, industry and society
- An officialy recognised non-profit organisation
- About 2000 members and 5000 individuals involved
- Large participation from industry (~50%)
- 19 «Clubs techniques» and 12 «Groupes régionaux»
- Organizes conferences and seminars
- Initiates/attracts 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

1883-2015: From SIE & SFE to SEE: 132 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

GSI'15 Sponsors

SMAI/SEE GSI'15

- 140 international attendees from 15 different countries
- 85 scientific presentations on 3 days
- 3 keynote speakers
  - Mathilde MARCOLLI (CallTech): "From Geometry and Physics to Computational Linguistics"
  - Tudor RATIU (EPFL): "Symmetry methods in geometric mechanics"
  - Marc ARNAUDON (Bordeaux University): "Stochastic Euler-Poincaré reduction"
- 1 Short Course
  - Chaired by Roger BALIAN
  - Dominique SPEHNER (Grenoble University): "Geometry on the set of quantum states and quantum correlations"
- 1 Guest speaker
  - Charles-Michel MARLE (UPMC): "Actions of Lie groups and Lie algebras on symplectic and Poisson manifolds. Application to Hamiltonian systems"
- Social events:
  - Welcome coktail at Ecole Polytechnique
  - Diner in Versailles Palace Gardens

GSI'15 Topics

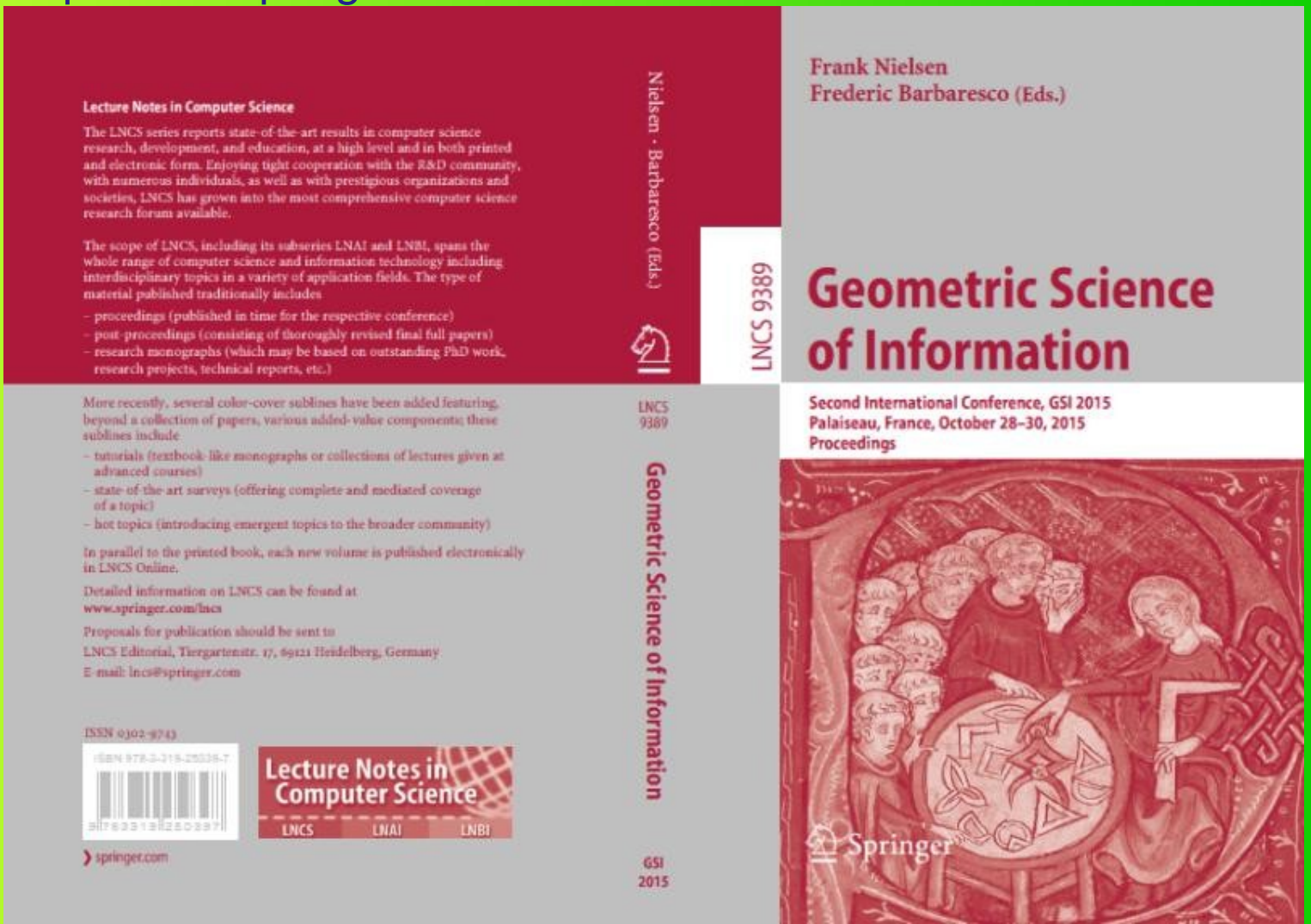
- GSI'15 federates skills from Geometry, Probability and Information Theory:
  - Dimension reduction on Riemannian manifolds
  - Optimal Transport and applications in Imagery/Statistics
  - Shape Space & Diffeomorphic mappings
  - Random Geometry/Homology
  - Hessian Information Geometry
  - Topological forms and Information
  - Information Geometry Optimization
  - Information Geometry in Image Analysis
  - Divergence Geometry
  - Optimization on Manifold
  - Lie Groups and Geometric Mechanics/Thermodynamics
  - Computational Information Geometry
  - Lie Groups: Novel Statistical and Computational Frontiers
  - Geometry of Time Series and Linear Dynamical systems
  - Bayesian and Information Geometry for Inverse Problems
  - Probability Density Estimation

GSI'15 Program

Wednesday October 28th		Thursday October 29th		Friday October 30th	
08.45-09.00 (Gay Lussac Amphi)					
Opening Session F. Barbaresco/F.Nielsen					
09.00-10.00 (Gay Lussac Amphi)		09.00-10.00 (Gay Lussac Amphi)		09.00-10.00 (Gay Lussac Amphi)	
Keynote Speaker chaired by D. Bennequin From Geometry and Physics to Computational Linguistics M. Marcolli (Caltech)		Keynote Speaker chaired by F. Nielsen Stochastic Euler-Poincaré Reduction M. Arnaudon (Bordeaux Univ.)		Keynote Speaker chaired by X. Pennec Symmetry Methods in Geometric Mechanics T. Ratiu (EPFL)	
10.00-10.30 Coffee Break		10.00-10.30 Coffee Break		10.00-10.30 Coffee Break	
10.30-12.30		10.30-12.30		10.30-12.30	
Becquerel Amphi	Gay Lussac Amphi	Becquerel Amphi	Gay Lussac Amphi	Becquerel Amphi	Gay Lussac Amphi
Random Geometry & Homology (L. Decreusefond/F. Chazal)	Computational Information Geometry (F. Nielsen/P. Marriot)	Information Geometry Optimization (G. Pistone/Y.Ollivier)	Geometry of Time Series & Linear Dynamical Systems (B. Afsari/A.Cont)	Dimension Reduction on Riemannian Manifolds (X. Pennec/A.Trouvé)	Optimization on Manifold (P.A. Absil/R. Sepulchre)
12.30-13.30 Lunch Break		12.30-13.30 Lunch Break		12.30-13.30 Lunch Break	
13.30-15.30		13.30-15.30		13.30-15.30	
Becquerel Amphi	Gay Lussac Amphi	Becquerel Amphi	Gay Lussac Amphi	Becquerel Amphi	Gay Lussac Amphi
Bayesian and Information Geometry for Inverse Problems (A. Djafari/O.Schwander)	Hessian Information Geometry (M.Boyom/S. Amari)	Optimal Transport (J.F. Marcotorchino/ A. Galichon)	Information Geometry in Image Analysis (G. Verddolaege/ Y. Berthoumieu)	Shape Space & Diffeomorphic mappings (S. Durrleman/ S. Allasonnière)	Lie Groups: Novel Statistical and Computational Frontiers (J. Jakubowicz/B. Afsari)
15.30-16.00 Coffee Break		15.30-16.00 Coffee Break		15.30-16.00 Coffee Break	
16.00-18.00		16.00-18.00		16.00-18.00	
Gay Lussac Amphi		Becquerel Amphi	Gay Lussac Amphi	Becquerel Amphi	Gay Lussac Amphi
Topological Forms and Information (D. Bennequin/P. Baudot)		Optimal Transport and applications in Imagery/Statistics (J. Bigot/B. Maury)	Probability Density Estimation (S. Said/J. Angulo)	Lie Groups and Geometric Mechanics/Thermodynamics (F. Barbaresco/G. de Saxcé)	Divergence Geometry (M. Broniatowski/I. Csiszar)
18.00-19.00 (Gay Lussac Amphi)		18.00-20.30		18.00-19.00 (Gay Lussac Amphi)	
Short Course chaired by R. Balian (CEA) Geometry on The Set of Quantum States and Quantum Correlations D.Spehner (Grenoble Univ.)		Social Event		Invited Speaker chaired by F. Barbaresco Actions of Lie groups and Lie algebras on symplectic and Poisson manifolds C.M. Marle (UPMC)	
19.00-20.00		20.30-23.30		19.00-19.15 (Gay Lussac Amphi)	
Cocktail (Ecole Polytechnique)		Gala Diner (Gardens of Versailles Palace)		Closing Session F. Barbaresco/F.Nielsen	

GSI'15 Proceedings

- Publication by SPRINGER in « Lecture Notes in Computer Science » LNCS vol. 9389 (800 pages), ISBN 978-3-319-25039-7
- http://www.springer.com/us/book/9783319250397

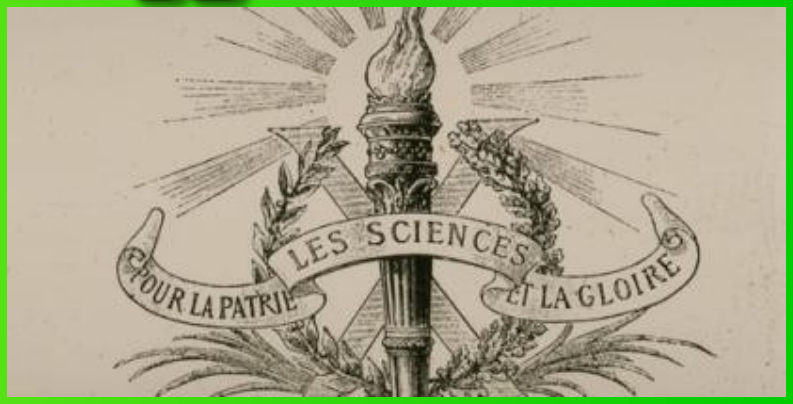


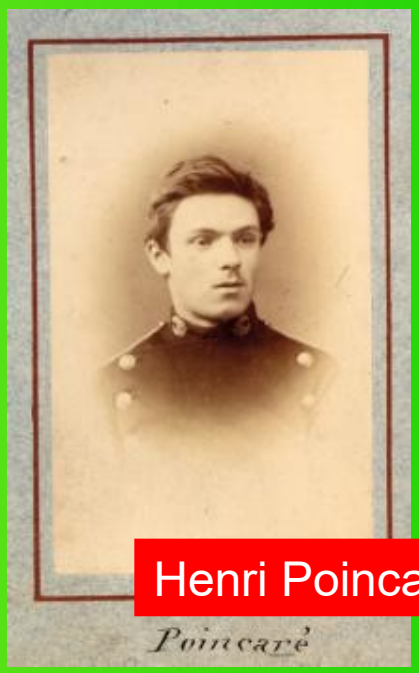
GSI'15 Special Issue

- Authors will be solicited to submit a paper in a special Issue "Differential Geometrical Theory of Statistics" in ENTROPY Journal, an international and interdisciplinary open access journal of entropy and information studies published monthly online by MDPI
- http://www.mdpi.com/journal/entropy/special_issues/entropy-statistics
- A book could be edited by MDPI: e.g.

Ecole Polytechnique

- Special thanks to « LIX » Department





Henri Poincaré – X1873

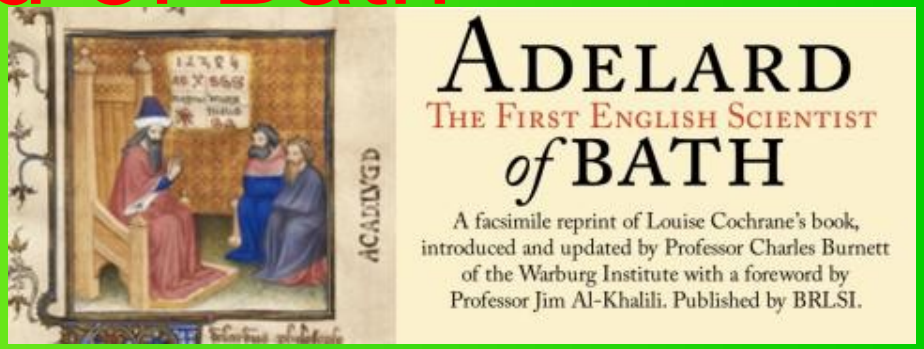
A product of the French Revolution and the Age of Enlightenment, École Polytechnique has a rich history that spans over 220 years.
https://www.polytechnique.edu/en/history

Paris-Saclay University in Top 8 World Innovation Hubs

http://www.technologyreview.com/news/517626/infographic-the-worlds-technology-hubs/

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.
- 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.

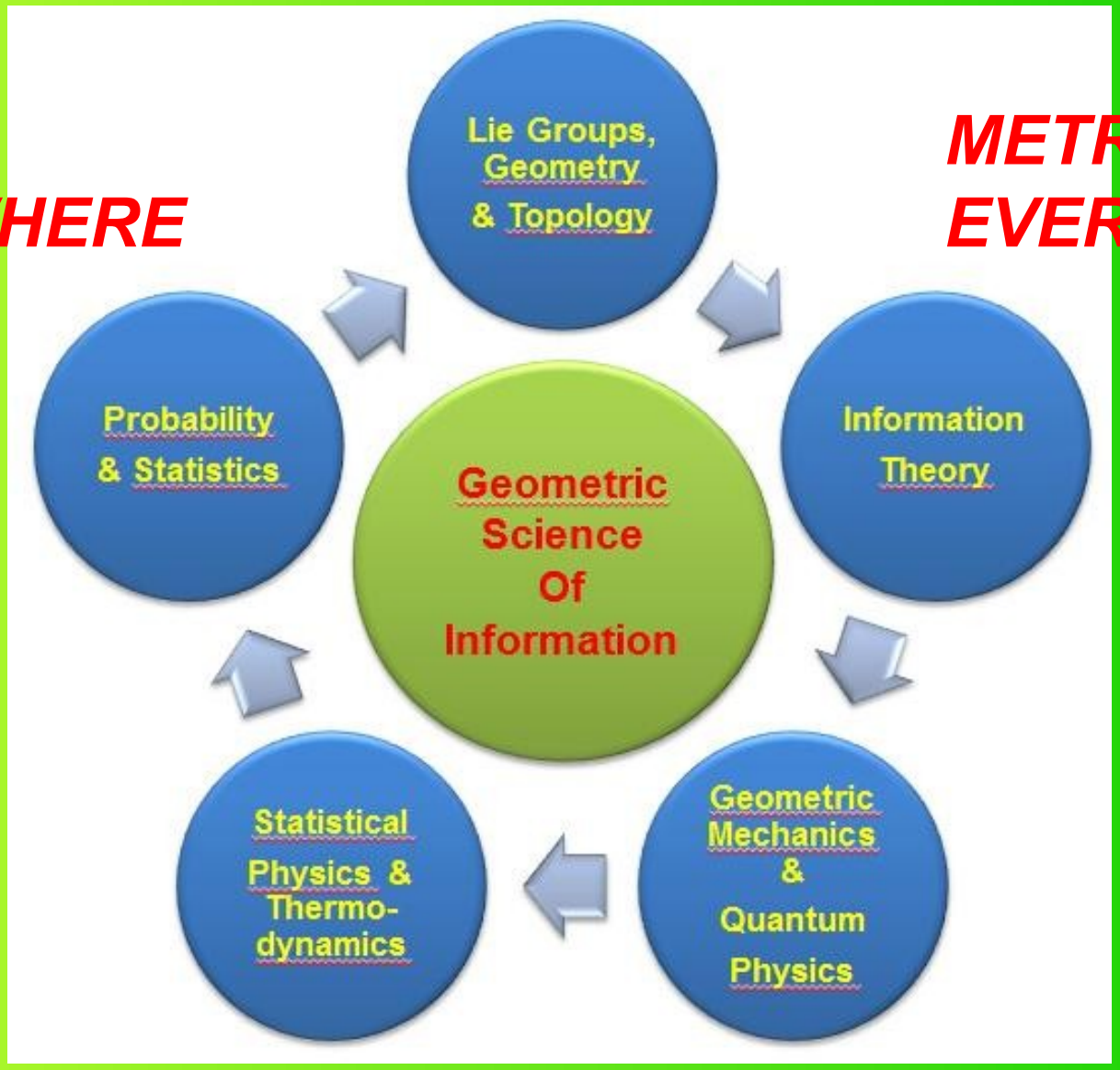
Adelard of Bath was the first to translate Euclid's Elements in Latin
Adelard of Bath has introduced the word « Algorismus » in Latin after his translation of Al Khuwarizmi

A new Grammar of Information

GROUP EVERYWHERE

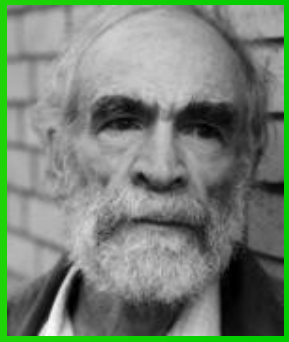
Elie Cartan

Henri Poincaré



METRIC EVERYWHERE

Maurice Fréchet



Misha Gromov

"*Mathematics is the art of giving the same name to different things*" – Henri Poincaré

Elie Cartan: Group Everywhere
(Henri Poincaré review of Cartan's Works)

RAPPORT SUR LES TRAVAUX DE M. CARTAN

fait à la Faculté des Sciences de l'Université de Paris.

PAR

H. POINCARÉ.

Si alors on dépouille la théorie mathématique de ce qui n'y apparaît que comme un accident, c'est-à-dire de sa matière, il ne restera que l'essentiel, c'est-à-dire la forme; et cette forme, qui constitue pour ainsi dire le squelette solide de la théorie, ce sera la structure du groupe.

M. CARTAN a fait faire des progrès importants à nos connaissances sur trois de ces catégories, la 1ère la 3e et la 4e. Il s'est principalement placé au point de vue le plus abstrait de la structure, de la forme pure, indépendamment de la matière, c'est-à-dire, dans l'espèce, du nombre et du choix des variables indépendantes.

Conclusions.

On voit que les problèmes traités par M. CARTAN sont parmi les plus importants, les plus abstraits et les plus généraux dont s'occupent les Mathématiques; ainsi que nous l'avons dit, la théorie des groupes est, pour ainsi dire, la Mathématique entière, dépouillée de sa matière et réduite à une forme pure. Cet extrême degré d'abstraction a sans doute rendu mon exposé un peu aride; pour faire apprécier chacun des résultats, il m'aurait fallu pour ainsi dire lui restituer la matière dont il avait été dépouillé; mais cette restitution peut se faire de mille façons différentes; et c'est cette forme unique que l'on retrouve ainsi sous une foule de vêtements divers, qui constitue le lien commun entre des théories mathématiques qu'on s'étonne souvent de trouver si voisines.

"the problems addressed by Elie Cartan are among the most important, most abstract and most general dealing with mathematics; group theory is, so to speak, the whole mathematics, stripped of its material and reduced to pure form. This extreme level of abstraction has probably made my presentation a little dry; to assess each of the results, I would have had virtually render him the material which he had been stripped; but this refund can be made in a thousand different ways; and this is the only form that can be found as well as a host of various garments, which is the common link between mathematical theories that are often surprised to find so near"

H. P

Maurice Fréchet: Metric Everywhere

LES ESPACES ABSTRAITS TOPOLOGIQUEMENT AFFINES.

PAR

MAURICE FRÉCHET

à STRASBOURG.

Un grand nombre des propriétés topologiques de l'espace euclidien s'étendent immédiatement à tous les espaces où une définition de la limite étant donnée (qui est en général imposée par la nature des éléments ou points de l'espace et les applications qu'on a en vue), cette définition peut s'exprimer par l'intermédiaire d'une *distance*.[1] Nous entendons par là qu'à tout couple A, B d'éléments ou points de l'espace considéré correspond un nombre $(A, B)=(B, A)\geq 0$, qui n'est nul que si A et B ne sont pas distincts et qui satisfait aux deux conditions suivantes:

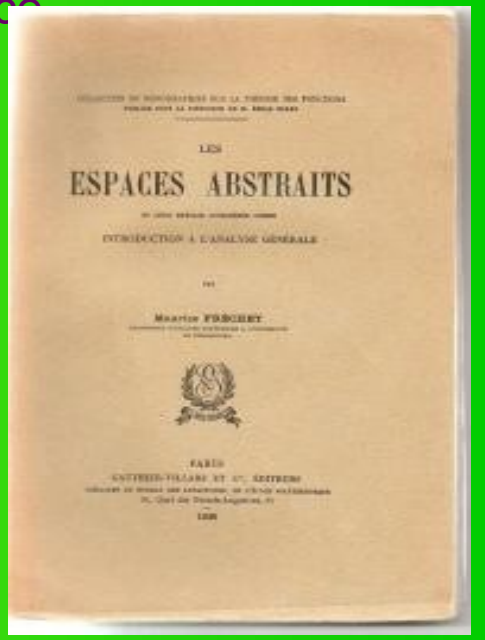
I. Pour trois points A, B, C arbitraires, on a toujours

$$(A, B)\leq(A, C)+(C, B).$$

II. La condition nécessaire et suffisante pour qu'une suite de points $A_1, A_2, \ldots$ de cet espace tende vers le point A de cet espace est que la distance (A, A_n) tende vers zéro.

Un tel espace sera appelé un espace (D) (initiale de distance).[1] Dans le cas où l'on n'impose pas la condition I, (A, B) sera un écart[1] et l'espace sera un espace (E)[1].

- Maurice Fréchet made major contributions to the topology of point sets and introduced the entire concept of metric spaces.
- His dissertation opened the entire field of functionals on metric spaces and introduced the notion of compactness.
- He has extended Probability in Metric spac

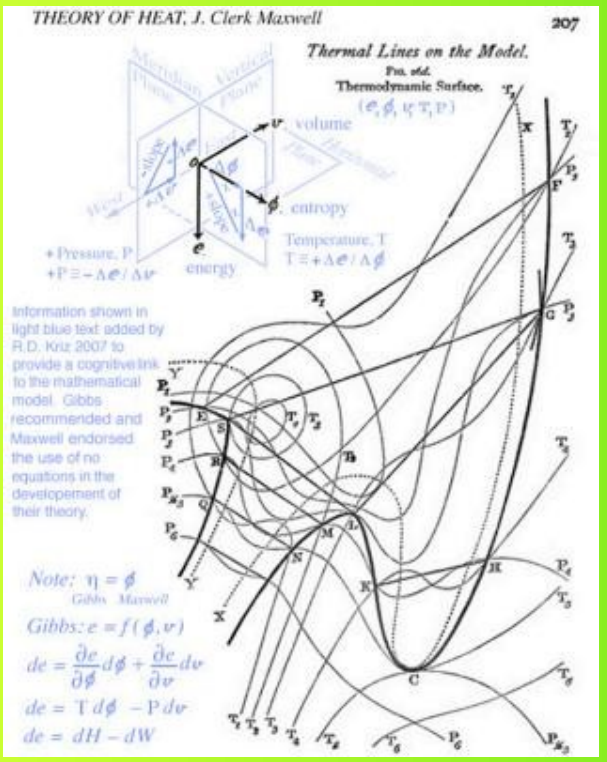


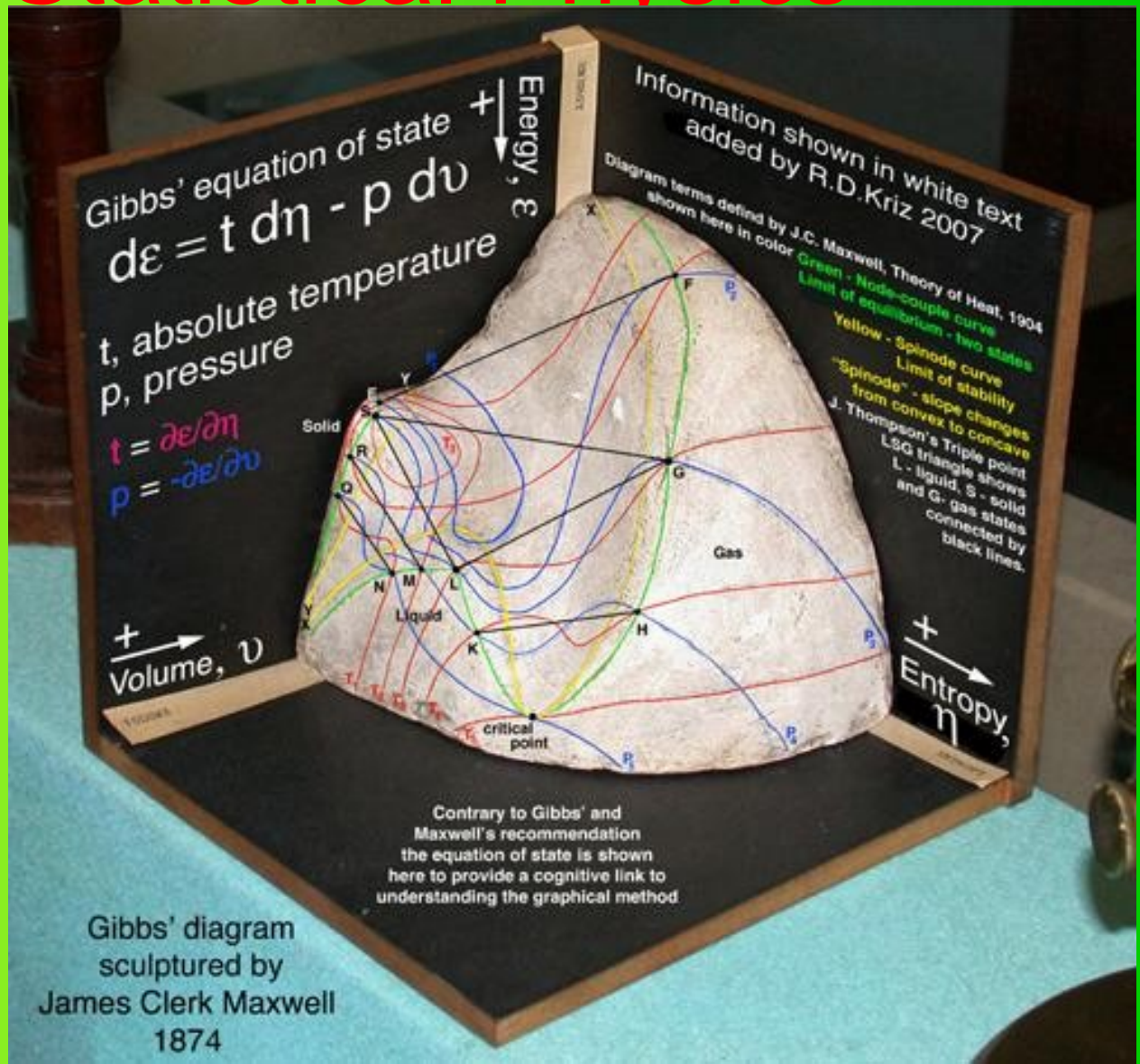
1948 (Annales de l'IHP)

Les éléments aléatoires de nature quelconque dans un espace distancié

Extension of Probability/Statistic in abstract/Metric space

Geometric Thermodynamics & Statistical Physics





GSI'15 & Geometric Mechanics

- The master of geometry during the last century, Elie Cartan, was the son of Joseph Cartan who was the village blacksmith.
- Elie recalled that his childhood had passed under "blows of the anvil, which started every morning from dawn".
- We can imagine easily that the child, Elie Cartan, watching his father Joseph "coding curvature" on metal between the hammer and the anvil, insidiously influencing Elie's mind with germinal intuition of fundamental geometric concepts.
- The etymology of the word "Forge", that comes from the late XIV century, "a smithy", from Old French forge "forge, smithy" (XII century), earlier faverge, from Latin fabrica "workshop, smith's shop", from faber (genitive fabri) "workman in hard materials, smith"

From Homo Sapiens to Homo Faber

"*Intelligence is the faculty of manufacturing artificial objects, especially tools to make tools, and of indefinitely varying the manufacture.*"
Henri Bergson

Venus at the Forge of Vulcan, Le Nain Brothers, Musée Saint-Denis, Reims

Into the Flaming Forge of Vulcan, Diego Velázquez, Museo Nacional del Prado

Bigorne

Bicorne

Enjoy all « Geometries »
(Diner at Versailles Palace Gardens)

Restaurant of
GSI'15 Gala Diner

Keynote Speakers

Talk chaired by
Daniel Bennequin

Prof. Mathilde MARCOLLI (CALTECH, USA)

From Geometry and Physics to Computational Linguistics

Abstact: I will show how techniques from geometry (algebraic geometry and topology) and physics (statistical physics) can be applied to Linguistics, in order to provide a computational approach to questions of syntactic structure and language evolution, within the context of Chomsky's Principles and Parameters framework.

Biography:

- Laurea in Physics, University of Milano, 1993
- Master of Science, Mathematics, University of Chicago, 1994
- PhD, Mathematics, University of Chicago, 1997
- Moore Instructor, Massachusetts Institute of Technology, 1997-2000
- Associate Professor (C3), Max Planck Institute for Mathematics, 2000-2008
- Professor, California Institute of Technology, 2008-present
- Distinguished Visiting Research Chair, Perimeter Institute for Theoretical Physics, 2013-present

.

Keynote Speakers

Prof. Marc ARNAUDON (Bordeaux University, France)

Stochastic Euler-Poincaré reduction

Abstact: We will prove a Euler-Poincaré reduction theorem for stochastic processes taking values in a Lie group, which is a generalization of the Lagrangian version of reduction and its associated variational principles. We will also show examples of its application to the rigid body and to the group of diffeomorphisms, which includes the Navier-Stokes equation on a bounded domain and the Camassa-Holm equation.

Biography:

Marc Arnaudon was born in France in 1965. He graduated from Ecole Normale Supérieure de Paris, France, in 1991. He received the PhD degree in mathematics and the Habilitation à diriger des Recherches degree from Strasbourg University, France, in January 1994 and January 1998 respectively. After postdoctoral research and teaching at Strasbourg, he began in September 1999 a full professor position in the Department of Mathematics at Poitiers University, France, where he was the head of the Probability Research Group. In January 2013 he left Poitiers and joined the Department of Mathematics of Bordeaux University, France, where he is a full professor in mathematics.

Talk chaired by Frank Nielsen

Keynote Speakers

Prof. Tudor RATIU (EPFL, Switzerland)

Symmetry methods in geometric mechanics

Abstact: The goal of these lectures is to show the influence of symmetry in various aspects of theoretical mechanics. Canonical actions of Lie groups on Poisson manifolds often give rise to conservation laws, encoded in modern language by the concept of momentum maps. Reduction methods lead to a deeper understanding of the dynamics of mechanical systems. Basic results in singular Hamiltonian reduction will be presented. The Lagrangian version of reduction and its associated variational principles will also be discussed. The understanding of symmetric bifurcation phenomena in for Hamiltonian systems are based on these reduction techniques. Time permitting, discrete versions of these geometric methods will also be discussed in the context of examples from elasticity.

Biography:

- BA in Mathematics, University of Timisoara, Romania, 1973
- MA in Applied Mathematics, University of Timisoara, Romania, 1974
- Ph.D. in Mathematics, University of California, Berkeley, 1980
- T.H. Hildebrandt Research Assistant Professor, University of Michigan, Ann Arbor, USA 1980-1983
- Associate Professor of Mathematics, University of Arizona, Tuscon, USA 1983-1988
- Professor of Mathematics, University of California, Santa Cruz, USA, 1988-2001
- Chaired Professor of Mathematics, Ecole Polytechnique Federale de Lausanne, Switzerland, 1998 - present
- Professor of Mathematics, Skolkovo Institute of Science and Technonology, Moscow, Russia, 2014 - present

Talk chaired by Xavier Pennec

Short Course

Prof. Dominique SPEHNER (Grenoble University)

Geometry on the set of quantum states and quantum correlations

Abstact: I will show that the set of states of a quantum system with a finite-dimensional Hilbert space can be equipped with various Riemannian distances having nice properties from a quantum information viewpoint, namely they are contractive under all physically allowed operations on the system. The corresponding metrics are quantum analogs of the Fisher metric and have been classified by D. Petz. Two distances are particularly relevant physically: the Bogoliubov-Kubo-Mori distance studied by R. Balian, Y. Alhassid and H. Reinhardt, and the Bures distance studied by A. Uhlmann and by S.L. Braunstein and C.M. Caves. The latter gives the quantum Fisher information playing an important role in quantum metrology. A way to measure the amount of quantum correlations (entanglement or quantum discord) in bipartite systems (that is, systems composed of two parties) with the help of these distances will be also discussed.

Biography:

- Diplôme d'Études Approfondies (DEA) in Theoretical Physics at the École Normale Supérieure de Lyon, 1994
- Civil Service (Service National de la Coopération), Technion Institute of Technology, Haifa, Israel, 1995-1996
- PhD in Theoretical Physics, Université Paul Sabatier, Toulouse, France, 1996-2000.
- Postdoctoral fellow, Pontificia Universidad Católica, Santiago, Chile, 2000-2001
- Research Associate, University of Duisburg-Essen, Germany, 2001-2005
- Maître de Conférences, Université Joseph Fourier, Grenoble, France, 2005-present
- Habilitation à diriger des Recherches (HDR), Université Grenoble Alpes, 2015
- Member of the Institut Fourier (since 2005) and the Laboratoire de Physique et Modélisation des Milieux Condensés (since 2013) of the university Grenoble

Talk chaired by Roger Balian

Guest Speakers

Prof. Charles-Michel MARLE (UPMC, France)

Actions of Lie groups and Lie algebras on symplectic and Poisson manifolds. Application to Hamiltonian systems

Abstact: I will present some tools in Symplectic and Poisson Geometry in view of their applications in Geometric Mechanics and Mathematical Physics. Lie group and Lie algebra actions on symplectic and Poisson manifolds, momentum maps and their equivariance properties, first integrals associated to symmetries of Hamiltonian systems will be discussed. Reduction methods taking advantage of symmetries will be discussed.

Biography:

Charles-Michel Marle was born in 1934; He studied at Ecole Polytechnique (1953-1955), Ecole Nationale Supérieure des Mines de Paris (1957-1958) and Ecole Nationale Supérieure du Pétrole et des Moteurs (1957-1958). He obtained a doctor's degree in Mathematics at the University of Paris in 1968. From 1959 to 1969 he worked as a research engineer at the Institut Français du Pétrole. He joined the Université de Besançon as Associate Professor in 1969, and the Université Pierre et Marie Curie, first as Associate Professor (1975) and then as full Professor (1981). His resarch works were first about fluid flows through porous media, then about Differential Geometry, Hamiltonian systems and applications in Mechanics and Mathematical Physics.

Talk chaired by Frédéric Barbaresco