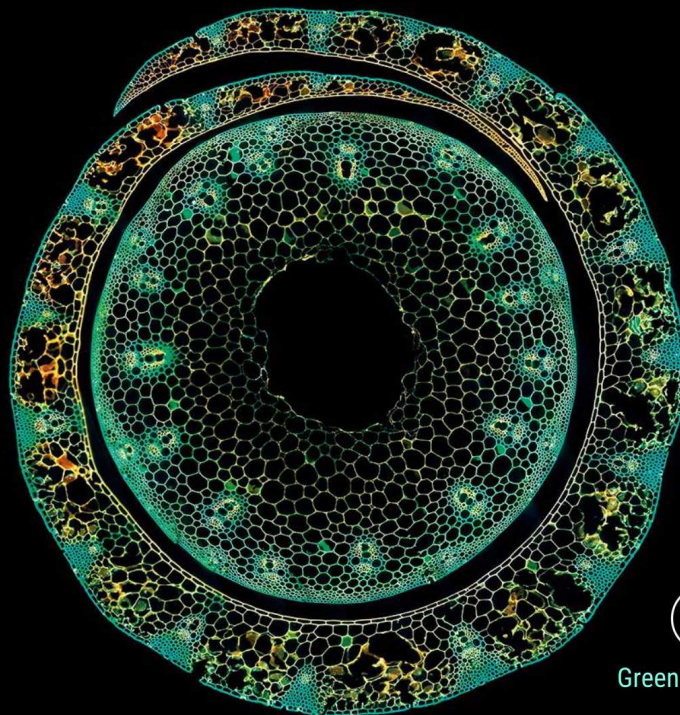




# TOPOLOGICAL & GEOMETRICAL STRUCTURES OF INFORMATION

AUGUST 28<sup>TH</sup> - SEPTEMBER 1<sup>ST</sup> 2017  
CIRM - MARSEILLE - FRANCE



Gg

Green geometry

Information-theoretic geometry of metric measure spaces (particular and general).

T.Courtade, N.Gozlan, D.Johnson, M.Ledoux, J.Maas, M.Madiman, K.T.Sturm.

Information and topology.

P.Baudot, D.Bennequin, M.Boyom, J.I.Burgos Gil, P.Elbaz-Vincent, H.Gangl, T.Leinster, M.Marcolli, J.Terilla.

Classical/Stoch. Geometric Mechanics & Lie Group Thermodynamics/Statistical Physics.

F.Barbaresco, J.Bensoam, F.Gay-Balmaz, F.Hélein, B.Maschke.

Geometry of quantum states and quantum correlations.

M.Guta, D.Spehner, K.Zyczkowski.

Quantum states of geometry and geometry of quantum states.

E.Livine, A.Marcianò, C.Rovelli.

Geometric Statistics on Manifolds and Shape Spaces.

S.Allasonnière, M.Arnaudon, S.Durrleman, I.Dryden, A.LeBrigant, A.Feragen, X.Pennec, A.Trounev.

Geometry of Information for Neural Networks, Machine Learning, Artificial Intelligence.

N.Ay, T.Fritz, L.Malago, F.Matúš, G.Montúfar, F.Nielsen, J.Rauh, M.Studený.

Mini-courses - Call for Communication-Poster - Special edition Entropy journal - Registration

<http://forum.cs-dc.org/category/94/tgsi2017> contact: [TGSi2017@gmail.com](mailto:TGSi2017@gmail.com)





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## General Informations

Website-Forum: <http://forum.cs-dc.org/category/94/tgsi2017>

CIRM website and registration: <http://scientific-events.weebly.com/1680.html>

The conference will take place at [CIRM](#) (Centre International de Rencontres Mathématiques) in Luminy Marseille, France, from August 28th to September 1st 2017. [Location & Information for visitors](#).

**Registration to the conference:** [Pre-registration before June 18th 2017](#).

The conference are free but registration is mandatory due to limited place, accomodation and catering is provided by CIRM with fees (see [CIRM](#) ).

**Call for Communication:** Poster sessions - deadline 15th of May 2017: [SUBMIT AN ABSTRACT](#) . Accepted abstracts will be proposed to submit an extended paper to a special edition of [Entropy journal \(MDPI\)](#) .

**Information – contact:** [TGSi2017@gmail.com](mailto:TGSi2017@gmail.com)

## Organising and Scientific Committee

[Stéphanie Allasonnière](#) (Paris V University, France)

[Marc Arnaudon](#) (IMB, France)

[Nihat Ay](#) (MPI-MIS, Germany)

[Pierre Baudot](#) (Inserm, France)

[Frédéric Barbaresco](#) (Thales, France)

[Daniel Bennequin](#) (Université Paris Diderot, France)

[Joël Bensoam](#) (Ircam, France)

[Michel Nguiffo Boyom](#) (Université Montpellier II, France)

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[Matilde Marcolli](#) (Caltech, USA)

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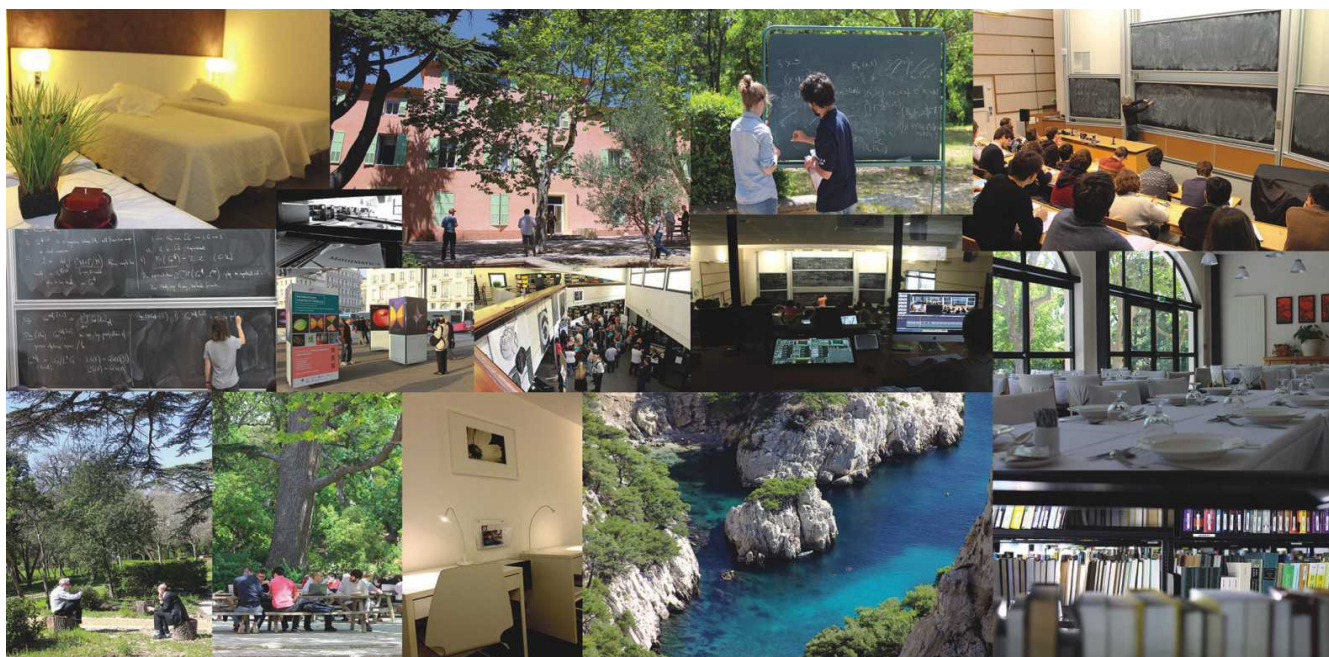
[Frank Nielsen](#) (École Polytechnique, France)

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[Carlo Rovelli](#) (CPT, France)

[Dominique Spenher](#) (Institut Fourier, France)

[John Terilla](#) (Queens College, USA)



## Presentation

TGSI2017 is dedicated to the geometrical and topological foundations of information theory. It will complement the 2017, 2016, 2015 and 2013 edition of "[Geometric science of information](#)" and "[Information Geometry and its Applications IV](#)", by focusing on the advances of entropy and information functions in probability, geometry, homology, algebra, category theory and their expression in physics and data analysis. There have been rapid recent developments in several different research communities in this connection, with little interaction between them, and one of the goals of the conference is to bring these communities in contact. Information theory lies at the intersection and nonetheless at the foundations of several scientific disciplines, statistical and quantum physics, complex systems including biology, cognition and social systems, and by definition information sciences and technologies ranging from computational aspects to signal and data analysis. Its industrial, social applications and impact is hardly quantifiable since the successive steps of maturation of the theory has accompanied and allowed the industrial and then the digital revolution (Nahin, P. J. *The Logician and the Engineer: How George Boole and Claude Shannon Created the Information Age*. Princeton University Press, 2012). As a consequence, information theory is probably the most obvious example of "the unreasonable effectiveness of mathematics in the natural sciences" including social sciences, both in its description and its construction. If entropy was only recognised recently to "possess the sense of humour", it kept on demonstrating us its sense of surprise, as shown by the first sentence of Borel's 1913 paper on irreversibility "It may seem pointless to return to a subject about which much has been written". In statistics, although analysis of the geometric structure of statistical manifolds (i.e., manifolds formed by some families of probability distributions) has its roots in work of Cramér, Rao and Fisher in the 1940's, it saw much development in the 1980's by Amari and others. On the other hand, the algebraic geometry of statistical models began to be studied more recently by Sturmfels and others. As underlined in the last INSMI report (prospective INSMI [rapport du comité national du CNRS, 2014](#)). "Since the early 2000s, the progresses in machine learning, Bayesian statistics, and model selection for example, have overwhelmed the domain. In particular, "geometric" methods have emerged, based on differential geometry and other geometries (Hessian, or Kähler or symplectic or contact...). This new family of methods are grouped under the generic term of information geometry." In physics, the geometric aspects of information theory played a key role in the formalisation and description of quantum states and correlations that are now investigated in the context of quantum gravity. Those new developments continuously renew the traditional hope that "tomorrow, we will

have learned to understand and express all of physics in the language of information" (J.A. Wheeler). In probability theory, it is now recognized that information-theoretic inequalities play a foundational role, being closely connected to central themes including limit theorems, concentration of measure, suprema of stochastic processes, convergence rates of Markov processes to stationarity, and so on. In convex geometry, entropy is closely connected to central questions like the hyperplane conjecture. In category, homology and homotopy theory, researches have advanced on the axiomatization and characterisation of information and probability theory, and could uncover some operad or motive related structures. In geometry, thanks to work of Lott, Villani and Sturm, entropy has provided new ways of talking about curvature for spaces without a Riemannian structure, which was inconceivable before.

The conferences will review many of these new developments involving the interplay of information and algebraic and differential geometry, number theory, probability and homology. The conference will emphasize the richness and diversity of information approaches and principles that arose in mathematics, physics, and statistical data analysis (...), and will pursue at the same time the perspective of establishing a coherent theory.

## Program

The conferences emphasize on an active participation of young researchers to discuss emerging topics of collaborative research. They are organised in half day and day sessions covering one central topic. Introductory courses open to students are proposed at the beginning of the sessions, then completed by more specialized one-hour presentation, and a session of working-discussion that tackle open questions and future development lines. [Paul Bourgin](#) will introduce and present the CS-DC Complex Systems Digital Campus - Unitwin Unesco.

### Session 1

#### [Information-theoretic geometry of metric measure spaces \(particular and general\)](#)

**Organisers:** [Michel Ledoux](#) (Institut de Mathématiques de Toulouse, France), [Mokshay Madiman](#) (University of Delaware, USA)

**Mini-course:** [Mokshay Madiman](#) (University of Delaware, USA)

**Speakers:** [Thomas Courtade](#) (University of California, Berkeley, USA) [Nathael Gozlan](#) (Université Paris-Est, France), [Oliver Johnson](#) (University of Bristol, UK), [Jan Maas](#) (IST, Austria).

**Abstract:** This session will explore the geometry of particular instances as well as general classes of metric measure spaces as captured using the notion of entropy.

### Session 2

#### [Information and topology](#)

**Organisers:** [Pierre Baudot](#) (INSERM, France), [Daniel Bennequin](#) (Université Paris Diderot, France), [Michel Boyom](#) (Université du Languedoc-Montpellier II, France), [Herbert Gangl](#) (Durham University, UK), [Matilde Marcolli](#) (Caltech, USA), [John Terilla](#) (Queens College, USA).

**Speakers:** [Pierre Baudot](#) (INSERM, France), [Daniel Bennequin](#) (Université Paris Diderot, France), [Michel Boyom](#) (Université du Languedoc-Montpellier II, France), [Philippe Elbaz-Vincent](#) (Institut Fourier), [Tom Leinster](#) (University of Edinburgh, UK), [Matilde Marcolli](#) (Caltech, USA), [John Terilla](#) (Queens College, USA).

**Abstract:** Arising from polylogarithmic functional equation, tropical semirings and probability theory studies, this session will address the progresses achieved in characterising the topology associated to information and probability theory, notably expressing some features of motive and operad.

### Session 3

#### [Classical/Stochastic Geometric Mechanics & Lie Group Thermodynamics/Statistical Physics](#)

**Organisers:** [Frédéric Barbaresco](#) (Thales, France), [Joël Bensoam](#) (IRCAM, France).

**Speakers:** [Frédéric Barbaresco](#) (Thales, France), [Joël Bensoam](#) (IRCAM, France), [François Gay-Balmaz](#) (LMD-ENS, France), [Frédéric Hélein](#) (Université Paris-Diderot, France), [Bernhard Maschke](#) (Claude Bernard University, France).

**Abstract:** This session will address methods of variational calculus combined with stochastic analysis, Multi-Symplectic Geometry and Lie Group theories to study foundations of Stochastic Geometric Mechanics and Lie Group Thermodynamics.

### Session 4

#### [Geometry of quantum states and quantum correlations](#)

**Organisers:** [Dominique Spehner](#) (Institut Fourier, France)

**Speakers:** [Madalin Guta](#) (University of Nottingham, UK), [Dominique Spehner](#) (Institut Fourier, France), [Karol Zyczkowski](#) (Jagiellonian University, Poland).

**Abstract:** The aim of this session is to explore the different Riemannian geometries that can be used to describe and quantify quantum correlations in composite quantum systems, together with their operational interpretations in quantum information theory.

### Session 5

#### [Quantum states of geometry and geometry of quantum states](#)

**Organisers:** [Carlo Rovelli](#) (Centre de Physique Theorique de Luminy, France)

**Speakers:** [Livine Etera](#) (Laboratoire de Physique, ENS Lyon, France), [Antonino Marcianò](#) (Fudan University, China), [Carlo Rovelli](#) (Centre de Physique Theorique de Luminy, France).

**Abstract:** The objective of the session is to make the point on the way geometry and quantum correlations are related in quantum gravity. The focus would be on the recent developments in the possibility of describing quantum states of the geometry with long distance correlations.

### Session 6

#### [Geometric Statistics on Manifolds and Shape Spaces](#)

**Organisers:** [Stéphanie Allasonnière](#) (Paris V University, France), [Xavier Pennec](#) (INRIA sophia, France)

**Mini-course:** [Xavier Pennec](#) (INRIA sophia, France), [Alain Trounev](#) (ENS Cachan, France)

**Speakers:** [Marc Arnaudon](#) (IMB, France), [Aasa Feragen](#) (DIKU, Denmark), [Stanley Durrleman](#) (ARAMIS lab, France), [Ian Dryden](#) (University of Nottingham, UK), [Alice Le Brigant](#) (IMB, Université de Bordeaux, France)

**Abstract:** This session presents recent progresses in geometric statistics. In many applications domains such as computational anatomy and phylogenetics, computer vision, structural biology, one models data as elements of a manifold which is quotiented by a proper and isometric Lie group action (a shape space).

## Session 7

### [Geometry of Information for Neural Networks, Machine Learning and Artificial Intelligence](#)

**Organisers:** [Nihat Ay](#) (MPI-MIS, Germany), [František Matúš](#) (Institute of Information Theory and Automation, Czech Republic)

**Speakers:** [Nihat Ay](#) (MPI-MIS, Germany), [Tobias Fritz](#) (Perimeter Institute, Canada), [Luigi Malago](#) (RIST, Romania), [František Matúš](#) (Institute of Information Theory and Automation, Czech Republic), [Guido Montúfar](#) (MPI-MIS, Germany), [Johannes Rauh](#) (Leibniz Universität, Germany), [Milan Studený](#) (Institute of Information Theory and Automation, Czech Republic).

**Abstract:** This session will review the role in network analysis within the fields of artificial intelligence and machine learning, of geometric objects defined in terms of information equalities as well as information inequalities.

## Poster Sessions - afternoons and after diners

### [Abstracts](#)

[Goffredo Chirco](#) (Albert Einstein Institute Potsdam, Germany) We study the extension of Souriau's formalism of Lie group thermodynamics to the case of reparametrization invariant systems, in the perspective of a general covariant reformulation of statistical mechanics compatible with the conceptual scheme of General Relativity.

[Maël Dugast](#) (Univ Lyon, UJM-Saint-Etienne, INSA Lyon, France), Guillaume Bouleux and Eric Marcon. The geometry of periodically correlated stochastic processes induced by the dilation.

[Simon Fong](#) (School of Computer Science, The University of Birmingham, UK) Joshua Knowles, and Peter Tiño. Induced Dualistic Structure and Probability Densities on Riemannian Manifolds.

[Antonia M Frassino](#) (Frankfurt Institute for Advanced Studies, Germany) and [Dimitri Marinelli](#) (Romanian Institute of Science and Technology) Deep learning and the universal quantum simulator, as meant by Feynmann, are machines able to build representations and can be used as efficient generative models...

[Edgar Guzman-Gonzalez](#) (Institute of Nuclear Sciences, UNAM, Mexico) Given a spin  $j$ , we define the spin shape space as the quotient of the space of the spin space under the action of the rotation group  $SO(3)$ .

[Hideyuki Ishi](#) (Nagoya University, Japan) We present a new class of convex cones consisting of real symmetric matrices.

[Marco Laudato](#) (University of Naples Federico II) Quantum and Tomographic Metrics from Relative Entropies.

[Leo Liberti](#) (CNRS LIX, Ecole Polytechnique, France) Random projections in optimization.

[Anton Mallasto](#) (University of Copenhagen, Denmark) : We introduce a novel framework for statistical analysis of populations of non-degenerate Gaussian processes (GPs), which are natural representations of uncertain curves...

[Fabio Maria Mele](#) (Naples University Federico II, Italy) Fisher Metric, Geometric Entanglement and Spin Networks.

[Hiroschi Matsuzoe](#) (Nagoya Institute of Technology, Japan) : A survey on infinite dimensional affine differential geometry and information geometry.

[Stéphane Puechmorel](#) (Ecole nationale de l'aviation civile, France) Natural metrics on the tangent bundle to a statistical manifold.

[Ha Quang Minh](#) (Istituto Italiano di Tecnologia, Italy) Infinite-dimensional Log-determinant Divergences between positive definite trace class operators.

[Eduardo Serrano-Ensástiga](#) (Institute for Nuclear Sciences, UNAM, Mexico) Study of the FS metric with the Majorana's stellar representation.

## Schedule

Time	Monday-28th	Tuesday-29th	Wednesday-30th	Thursday-31st	Friday-1st
08:30-09:25	Introduction CS-DC Unesco-Unitwin P.Bourgine	S2. info topo D.Bennequin	S3. Geo Meca Stat Minicourse J.Bensoam	S4. Geo Quant Corr Minicourse 1H30 C. Zyczkowski	S6. Geo Stat Shape A.Feragen
09:25-10:20	S1. metric measure Minicourse M.Madiman	S2. info topo M.Marcolli	S3. Geo Meca Stat F.Helein	S4. Geo Quant Corr D.Spehner 30'	S6. Geo Stat Shape S.Durreleman
10:20-10:40	Tea-Coffee Break	Tea-Coffee Break	Tea-Coffee Break	Tea-Coffee Break	Tea-Coffee Break
10:40-11:35	S1. metric measure N.Gozlan	S2. info topo T.Leinster	S3. Geo Meca Stat B.Maschke	S4. Geo Quant Corr M.Guta	S6. Geo Stat Shape I.Dryden
11:35-12:30	S1. metric measure O.Johnson	S2. info topo J.Terrila	S3. Geo Meca Stat F.Barbaresco	S5. Geo Quant Gravi C.Rovelli	S7. MachLearnNeurNet N.Ay & F.Matúš
12:30-13:30	Lunch	Lunch	Lunch	Lunch	Lunch
13:30-14:25	S1. metric measure J.Mass	S2. info topo P. Elbaz-Vincent	S3. Geo Meca Stat F.Gay-Balmaz	S5. Geo Quant Gravi Etera Livine	S7. MachLearnNeurNet T.Fritz
14:25-15:20	S1. metric measure T.Courtade	S2. info topo M.Boyom	S7. MachLearnNeuNet L.Malago	S5. Geo Quant Gravi A.Marciano	S7. MachLearnNeurNet G.Montúfar
15:20-15:40	Tea-Coffee Break	Tea-Coffee Break	Tea-Coffee Break	Tea-Coffee Break	Tea-Coffee Break
15:40-16:35	Discussion Poster session	S2. info topo P.Baudot	Free time - Visit Calanques	S6. Geo Stat Shape Minicourse X.Pennec, A.Trouvé	S7. MachLearnNeurNet J.Rauh
16:35-17:30		Discussion Poster session	Free time - Visit Calanques	S6. Geo Stat Shape A.Lebrigand- M.Arnaudon	S7. MachLearnNeurNet M.Studený
17:30-18:30			Discussion Poster session	Discussion Poster session	
19:30-21:00	Diner	Diner	Diner	Diner	

## Sponsors & Partners

**Administration:** We thank **Fanny Pra**, **Jennifer Bedigian** (Inserm UMR10\_72 UNIS) and **Laure Stefanini**, **Olivia Barbaroux** and all **CIRM's administration** for the great work and help on the organisation and administrative aspects.



- [CIRM](#) Centre International de Rencontres Mathématiques (Accommodation - Catering Conference center - Video)
- [Aix Marseille Université](#), [Fondation AMU](#) (funding)
- [INSERM UNIS1072](#) (Logistic – Financial Host)
- [GDR Dynamique Quantique](#) (funding)
- [GDR MIA Mathématiques de l'Imagerie et de ses Applications](#) (funding - diffusion)
- [GDR ISIS Information, Signal, Image et ViSion](#) (funding - diffusion)
- [GDR Géométrie stochastique](#) (funding - diffusion)
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