PAPER AWARDS GSI 2025

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PAPER AWARDS GSI 2025

Interaction instead of Competition

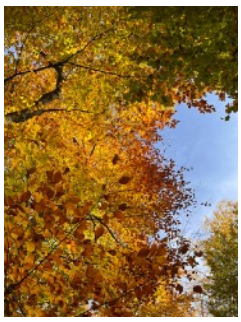
Prize Committee 2025

Alice Barbora Tumpach served as President of the Prize Committee 2025

Frank Nielsen is the General co-chair of GSI

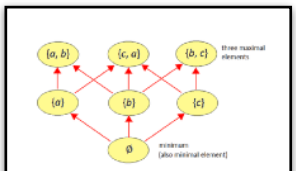
Frédéric Barbaresco is the General co-chair of GSI

7th International Conference on GEOMETRIC SCIENCE OF INFORMATION GSI'25 Saint-Malo, France 29th to 31st October 2025



I was asked to select the best candidates for the Best Paper Award and the Best Student Paper Award. This would have been easy if the set of papers submitted to GSI 2025 had been a totally ordered set. Alas, GSI is a colorful conference that aims to promote interactions between different fields. How can we compare a paper on Symplectic Geometry and a paper on Geometric Statistics? How were we to choose between the beautiful paper by Olivier Rioul correcting the historical inaccuracies surrounding the Schützenberger-Van Trees inequality and drawing inspiration from Schützenberger's original idea to propose new developments, and the precise mathematical resolution of the equations determining our possible GPS positions according to our distances to satellites by Mireille Boutin and collaborators? Both papers are questioning conventional wisdom and both are extremely useful beyond our community. Yet they are not comparable. Is history more important than the present, or is it more important to dismantle current preconceptions than historical beliefs? My opinion is that both are fundamental. They are also prototype examples of the ability that mathematicians have to question everything, in particular hypotheses that others take for granted, as well as their perseverance in seeking out the truth. These abilities are our most precious treasure, the one that humankind needs most from us now, particularly in the AI area, where the boundaries between what is logically funded and what just looks like it is are blurred.

The set of papers submitted to GSI 2025 is definitely not a totally ordered one. Is it at least partially ordered? Even the papers belonging to the same subfield of Information Geometry resemble the leaves of a physical tree (like the one on the upper right corner) more than they resemble a partially ordered set on which we could apply Zorn's Lemma (see the bottom of this page) to get a maximal element. This maximal element may not be unique anyway, as demonstrated by the example on the right. So why do we pretend that there should be a Best Paper? Why this use of the superlative clause? To put us in competition? Do we really need that? I don't think so.



Picture taken from https://mathstrek.blog/2020/03/30/commutative-

A partially ordered set in which every totally ordered subset has an upper bound admits a maximal element according to Zorn's Lemma. But this maximal element may not be unique.

CATEGORIES OF AWARDS
- Questioning the Physics of today and the Physics of the past
- Extracting Structures
- Fundamental Tools
- Questioning the World
- Questioning History
- Marvelous Presentation

For this Papers Awards Ceremony, I decided to celebrate the diversity of your contributions based on key pillars representing possible ways to do research and improve current knowledge. Like the set of participants in the GSI conference, the papers submitted this year are connected to each other, building a compact foliage from the bottom to the top. The top itself is not inert and depends on how the wind blows.

Alice Barbora Tumpach, President of the Prize Committee 2025.

Definition 20.3.1. Let $\preceq$ be a partial order on a set X. Then a **chain** $C \subseteq X$ is a nonempty, totally ordered subset, that is, for all $x, y \in C$ either $x \preceq y$ or $y \preceq x$.

Lemma 20.3.2 (Zorn's Lemma). *If X is a nonempty partially ordered set in which every chain has an upper bound, then X has a maximal element.*

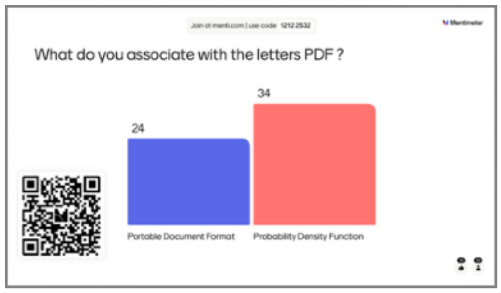
Recall that an **upper bound** u on a subset C of X means that $x \preceq u$ for all $x \in C$. A **maximal element** $\mu \in X$ means that if $x \in X$ and $\mu \preceq x$ then $\mu = x$.

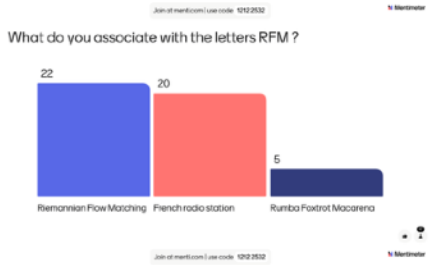
HIGHLIGHTS OF THE CEREMONY

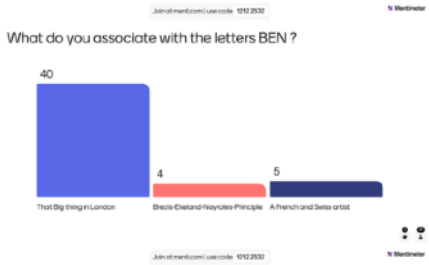
When Acronyms divide us...

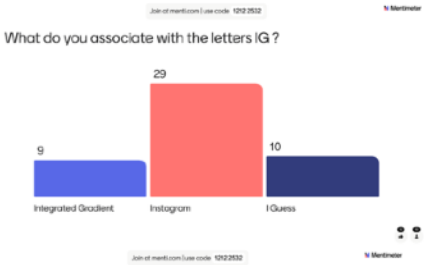
The acronym craze is in full swing. Every day, new combinations of letters appear, giving a sense of belonging to those who understand them and excluding others. Is it the need to mark one's territory that drives more and more authors to invent acronyms for things that have sometimes been around for a long time? What is certain is that this creates unnecessary barriers between fields. A way to protect oneself? Perhaps. A way to feel unique? Probably. What will be the next trendy acronym? RSS for Riemannian Symmetric Spaces? Or does it mean Rich Site Summary? We can expect that fields that use a high proportion of acronyms will tend to close in on themselves and die, while those that are more inclusive will grow thanks to the creativity of new followers.

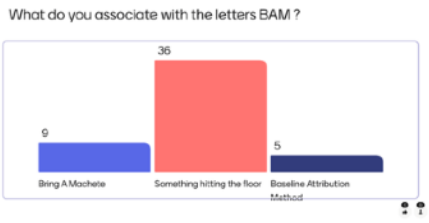
In a mentimeter prepared by Héloïse Guéritaud, some acronyms extracted from papers submitted to GSI where given a possible meaning. The experience was quite instructive! Below some screenshots of the results.

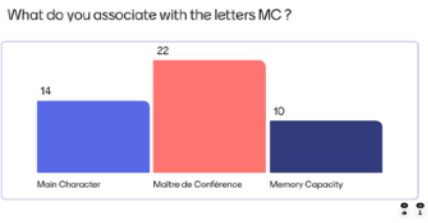












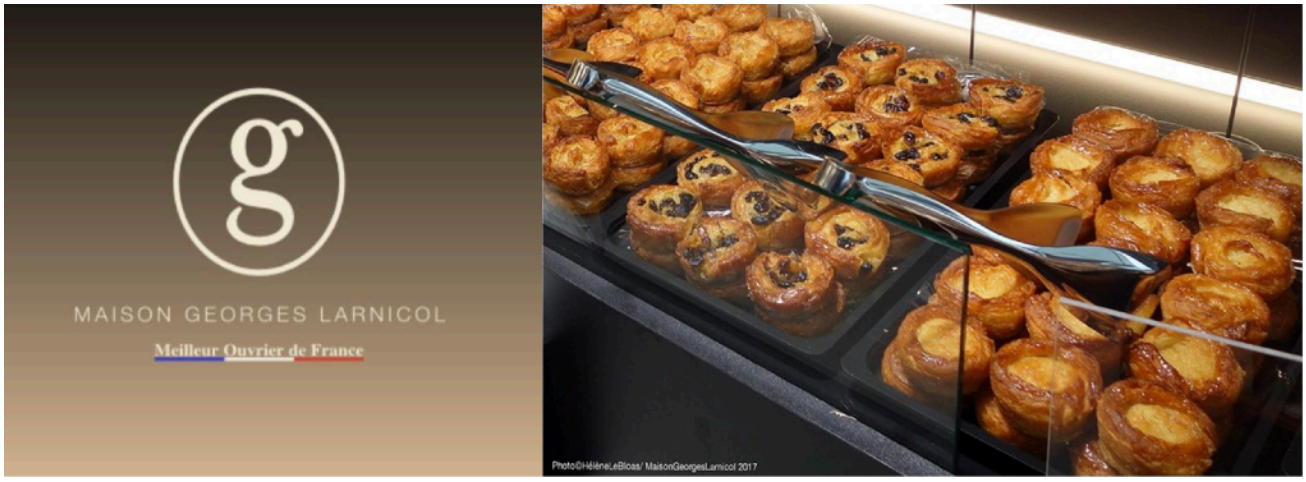
HIGHLIGHTS OF THE CEREMONY

Kouign-amann nerver lies...

According to Wikipedia, the Kouign-amann is a sweet, round **Breton laminated dough** pastry, originally made with bread dough, but is also made with laminated **viennoiserie** dough, containing layers of butter and incorporated sugar, similar in fashion to **puff pastry** albeit with fewer layers. It is slowly baked until the sugar **caramelizes** and steam from the water in the butter expands the dough, resulting in its layered structure. A smaller version, kouignette, is similar to a muffin-shaped, caramelized **croissant**.

A specialty of the town of **Douarnenez** in **Finistère**, **Brittany**, where it originated around 1860, the pastry is attributed to Yves-René Scordia (1828–1878). The name comes from the **Breton language** words for 'cake' (**kouign**) and 'butter' (**amann**), and in 2011 the **New York Times** described it as "the fattiest pastry in all of Europe."

The authors of the selected papers for the Best Paper Award and the Best Student Paper Award (see the list on page 11), more precisely those who were present at the Awards Ceremony, received a box of kouignettes prepared by Maison George Larnicol, Meilleur Ouvrier de France (Best Craftsman in France). We hope that next time, nobody will miss the ceremony!




The 7th international conference on Geometric Science of Information

Best Paper Award

GSI 2025
October 29th-31st 2025
Saint-Malo

PRESENTED TO
Géry de Saxcé

AUTHOR OF THE PAPER
A new symmetry group for Physics to revisit the Kaluza-Klein theory

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Géry de Saxcé

Géry de Saxcé is Emeritus Professor of the University of Lille. Before, he held positions in the Universities of Liège, Compiègne and Mons. He was project initiator next coordinator of the Erasmus Mundus Joint Master Degree "STRAINS". From 2013 to 2016, he was Chairman of the Committee of AUM, Academic group of the French Association of Mechanics (AFM). He is member of the French National Committee of Mechanics (CNFM). He developed variational approaches for dissipative dynamic systems in non smooth mechanics to study problems such that frictional contact and non associated plasticity for which, using tools of convex analysis, he introduced the concept of bipotential. His researches concern also geometrical approaches of the mechanics and thermodynamics of continua based on the Galilean relativity, the symplectic mechanics and the concept of affine tensor.

BEST PAPER AWARD

SPRINGER NATURE

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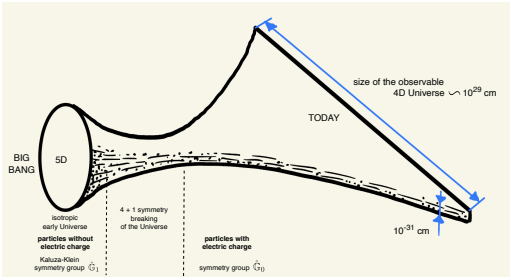
A new symmetry group for Physics to revisit the Kaluza-Klein theory

In his inspiring article, presented in a highly entertaining manner at GSI 2025, Géry de Saxcé explores the physics of the universe from its beginnings to the present day. Using the coadjoint orbit method, a theory introduced by Alexander A. Kirillov and developed in particular by Jean-Marie Souriau, he shows that electric charge is not conserved by the action of the Kaluza-Klein group of 5D affine transformations preserving a metric of signature 1 + 4. How can we reconcile the conservation of electric charge as we know it today with the action of this symmetric group of the Universe?



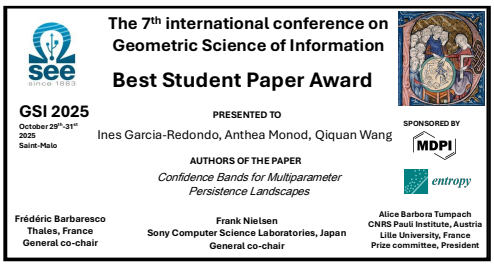
Géry de Saxcé proposes a three-phase scenario:

- Close to the event known as the Big Bang, in the early 5D universe, electric charge is not conserved, the Universe is isotropic but unstable, with symmetry group the Kaluza-Klein group.

- In the second phase, the first three spatial dimensions expand while the last one contracts.

- The last phase corresponds to the current stage of the universe, with an overwhelmingly small (10^{-31} cm) 5th dimension. The electric charge corresponds to one of the conserved moments of a 15-dimensional symmetry group, identified by Géry de Saxcé. He built an associated symmetric affine connection that allows to write the law of motion in a covariant way including the Lorentz force. On this basis, he proposed a variational principle that allows to find new coupled equations of the gravitation and electromagnetic fields.

The Kaluza-Klein theory, presented by Géry de Saxcé, provides a unified theory merging the gravitational and electromagnetic forces, relevant in the early Universe.


The 7th international conference on Geometric Science of Information

Best Student Paper Award

GSI 2025
October 29th-31st 2025
Saint-Malo

PRESENTED TO
Ines Garcia-Redondo, Anthea Monod, Qiquan Wang

AUTHORS OF THE PAPER
Confidence Bands for Multiparameter Persistence Landscapes

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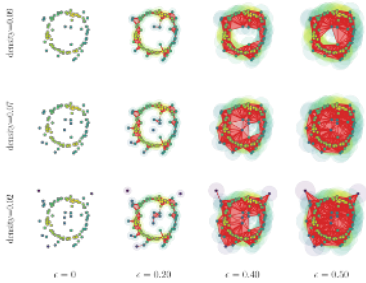
Lille University, France
Prize committee, President

BEST STUDENT PAPER AWARD

Confidence Bands for Multiparameter Persistent Landscapes

The field of topological data analysis develops robust frameworks and computationally efficient algorithms for extracting topological descriptors from data with the aim of capturing its underlying shape and structure. In this paper, written by Inés García-Redondo and Qiquan Wang under the supervision of Anthea Monod, and presented in a very didactic manner by Qiquan Wang during the session on Geometric Statistics, a Functional Central Limit Theorem for multiparameter persistence landscapes is derived. This work presents one of the first guarantees in theoretical statistics for multiparameter persistent homology, a setting which is significantly more algebraically complex than the single-parameter counterpart and which allows for the incorporation of density robustness. Confidence bands were calculated and implemented in an open-source algorithm available at https://github.com/inesgare/bands-mph-landscapes.



Qiquan Wang

Qiquan Wang is PhD student enrolled in the joint Imperial-Oxford StatML CDT, supervised both by Dr Anthea Monod and Dr Matthew Williams. Her research interests lie at the intersection of topological data analysis with statistics and machine learning.

Inés García-Redondo

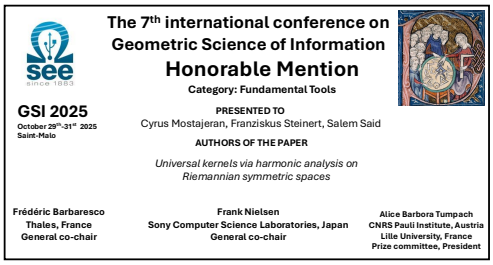
Inés García-Redondo has just started a postdoctoral researcher position at the University of Fribourg in the AIDOS Lab group. She completed her PhD at the

London School of Geometry and Number Theory, a joint programme between Imperial College London, University College of London and King's College London. Her research focuses on algebraic topology and its application to data science and machine learning.

Anthea Monod

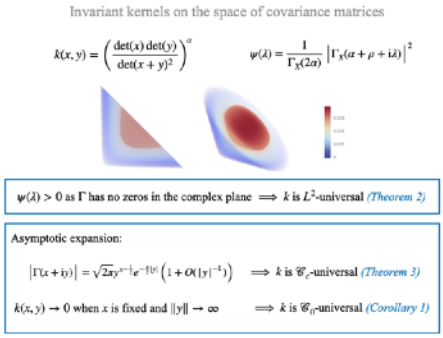
Qiquan Wang and Inés García-Redondo worked under the supervision of Dr Anthea Monod, a Reader (Associate Professor) in Mathematics and Machine Learning at the Department of Mathematics at Imperial College London. Her research uses theory from pure mathematics (algebraic geometry and algebraic topology) to develop computational, statistical, and machine learning methods for data that have complex topological structures. One of her significant research areas is to advance the current understanding of deep learning and modern AI technology, which is supported by a £10M UK government-funded EPSRC Mathematical and Computational Foundations of Artificial Intelligence Hub [EP/Y028872/1]. As a Co-Director of this AI Hub, she leads in scientific and operational strategy to harness theory from algebra, geometry, and topology to understand how AI systems work and build the next generation of efficient and reliable AI.

HONORABLE MENTION
in the category
FUNDAMENTAL TOOLS



Universal kernels via harmonic analysis on Riemannian symmetric spaces

As kernel methods develop in machine learning algorithms on non-Euclidean spaces, it is essential to question the class of functions that can be approximated in the associated reproducing kernel Hilbert space, in other words, the expressivity of the models. In their work presented at GSI 2025, Cyrus Mostajeran, Salem Said and Franziskus Steinert establish fundamental tools for studying the universality properties of kernels in Riemannian symmetric spaces with negative curvature, such as the manifold of positive definite symmetric matrices or the hyperbolic space. In a series of mathematical results whose foundations are based on the theory of roots in semisimple Lie algebras, the authors provide the link between universality properties of kernels and properties of their spectral measures. Moreover, they applied their results on several kernels from the literature providing theoretical justification for their use in applications involving manifold-valued data.



Salem Said

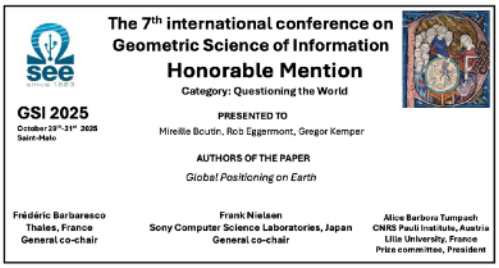
Salem Said is research scientist at the French National Centre for Scientific Research (CNRS). He works at Laboratoire Jean Kuntzmann, within Université Grenoble Alpes. He obtained his PhD in 2009, in Grenoble, and has since then always been interested in Lie groups and harmonic analysis, and their interactions with statistics and machine learning. He is proud father of two little girls.

Franziskus Steinert

Franziskus Steinert completed a bachelor's in finance in Frankfurt am Main before transitioning to mathematics. He studied math at undergraduate level at ETH Zurich and did a master's in Cambridge focusing on PDE theory. He then joined NTU Singapore as a Research Associate under Prof. Mostajeran.

Cyrus Mostajeran

Cyrus is an Assistant Professor in Applied Mathematics at the School of Physical and Mathematical Sciences at Nanyang Technological University (NTU) in Singapore and a Bye-Fellow at Fitzwilliam College in the University of Cambridge. Previously, he was an Early Career Research Fellow at the University of Cambridge. Cyrus studied mathematics as an undergraduate at the University of Oxford before doing graduate work in mathematics, physics, and engineering, earning a PhD in Information Engineering from the University of Cambridge in 2018 under the supervision of Professor Rodolphe Sepulchre. His research interests include the application of geometry to problems arising in optimization, learning, and robotics.


The 7th international conference on Geometric Science of Information
Honorable Mention
Category: Questioning the World
GSI 2025
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PRESENTED TO
Mireille Boutin, Rob Eggermont, Gregor Kemper
AUTHORS OF THE PAPER
Global Positioning on Earth
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Frank Nielsen
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General co-chair
Alice Barbora Tumpach
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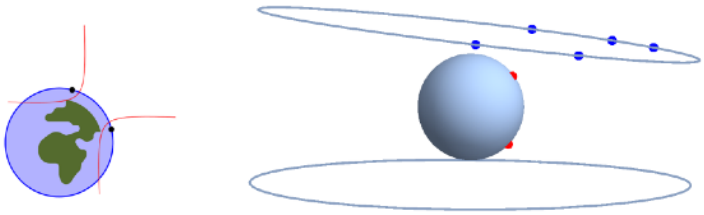
Prize committee, President

HONORABLE MENTION in the category QUESTIONING THE WORLD

Global Positioning on Earth



In this paper, presented in a very comprehensible way by Mireille Boutin at GSI 2025 and written in collaboration with Rob Eggermont and Gregor Kemper, the authors question the common assumption that having four satellites in view guarantees that the global positioning problem has a unique solution on earth. Deriving explicitly the solutions of the global positioning problem, the authors show that this assumption is in fact incorrect. Even when constraining the solution to a sphere, this problem can still have two solutions. Moreover, for any pair of points on a sphere, there is a family of hyperboloids of revolution such that if the satellites are placed on one sheet of one of these hyperboloid (see picture), then the global positioning problem has both points as solutions. With three satellites in view, the authors show that there can be up to four solutions on the sphere. From a numerical point of view, the authors propose an algorithm that outputs the possible positions of a user on Earth receiving noisy satellite data. This simple numerical procedure consists in obtaining two initial guesses analytically using the assumption that the user is constrained on a sphere and refining those guesses using an iterative numerical approach.

Rob Eggermont

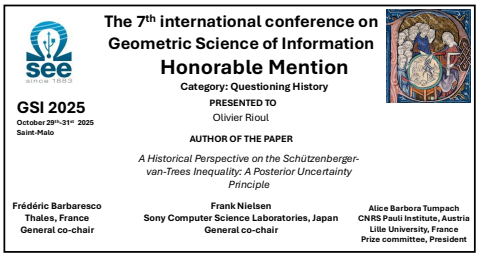
Rob Eggermont graduated with a M.Sc. In Mathematics at Leiden University in 2011. He received his Ph.D. in Mathematics at the Eindhoven University of Technology in 2015 under the supervision of Jan Draisma. After a post-doc at the University of Michigan, he returned to Eindhoven in 2017. His research focuses on finiteness properties in settings of variable or infinite dimension with symmetry, as well as the general theory and structure of these settings. He is also interested in applied problems with a strong algebraic and/or geometric flavour, such as localization problems.

Gregor Kemper

Gregor Kemper received his doctorate in 1994 from the University of Heidelberg, Germany, under the direction of B.H. Matzat. After holding various post-doctoral positions in Heidelberg and spending seven months as an Adjunct Assistant Professor at Queen's University in Kingston, Ontario, he took a position as full professor at the Mathematics Department of the Technical University of Munich in 2002,which he currently holds. His interests focus on algorithmic algebra, invariant theory, commutative algebra, and distance geometry. He has co-authors on six continents.

Mireille Boutin

Mireille Boutin graduated with a B.Sc. in Physics-Mathematics from the University of Montreal in 1996. She received the Ph.D. degree in Mathematics from the University of Minnesota in 2001 under the direction of Peter J. Olver. After a post-doctorate at Brown University followed by a post-doctorate at the Max Plank Institute for Mathematics in the Sciences in Leipzig, she joined the faculty of Purdue university. In 2024, she left the US for the Netherlands and joined the Technical University of Eindhoven to lead the Discrete Algebra and Geometry group in the Department of Mathematics and Computer Science. She is currently an associate editor for the Journal of Mathematical Imaging and Vision. She previously served as Associate Editor for the journals IEEE Signal Processing Letters, IEEE Transactions on Image Processing, Applicable Algebra in Engineering, Communication and Computing, La Matematica, and the SIAM Journal on Applied Algebra and Geometry.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A Historical Perspective on the Schützenberger-van-Trees Inequality: A Posterior Uncertainty Principle
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Prize committee, President

Olivier Rioul

Olivier Rioul (https://perso.telecom-paristech.fr/rioul/) is Full Professor at the Department of Communication and Electronics at Télécom Paris, Institut Polytechnique de Paris, France. He graduated from École Polytechnique and from École Nationale Supérieure des Télécommunications, Paris, France, where he obtained his PhD degree. His research interests are in applied mathematics and include various, sometimes unconventional, applications of information theory such as inequalities in statistics, hardware security, and experimental psychology. He has been teaching information theory and statistics at various universities for twenty years and has published a textbook which has become a classical French reference in the field.

HONORABLE MENTION in the category QUESTIONING HISTORY

A Historical Perspective on the Schützenberger-van-Trees Inequality: A Posterior Uncertainty Principle

The Bayesian Cramér-Rao Bound (BCRB) is generally attributed to Van Trees who published it in 1968. According to Stigler's law of eponymy, no scientific discovery is named after its first discoverer. This is the case not only for the Cramér-Rao bound itself—due in particular to the French mathematicians Fréchet and Darmois—but also for the van Trees inequality: The French physician, geneticist, epidemiologist and mathematician Marcel-Paul (Marco) Schützenberger, in a paper of just fifteen lines written in 1956 (see picture)—more than a decade before van Trees—had not only derived the BCRB but, as a close examination of his proof shows, used a very original approach based on the Weyl-Heisenberg uncertainty principle on the square root of the posterior distribution. The work of Olivier Rioul is not only correcting the historical facts surrounding the Schützenberger-Van Trees inequality but also drawing inspiration from the Schützenberger's original idea to propose new developments and extends Schützenberger's approach to Fisher information matrices, which opens up new perspectives.

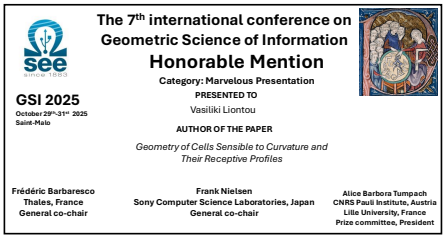
321*t*. M. P. Schützenberger: *A generalization of the Fréchet-Cramér inequality to the case of Bayes estimation.*

Let $f(x)$ be the a priori density function of x; $g(y|x)$ the conditional density function of y. For fixed x, the set of n independent y-variates is represented by z. The density function of z is $f'(z)$ and $g'(x|z)$ is the a posteriori density function of x, for given z. The a posteriori variance of the Bayes estimate is $v_z^2 = \int (x-z)^2 g'(x|z)\,dx$ and $v^2 = E_z v_z^2 = \int v_z^2 f'(z)\,dz$ is its average over z. $F = \int (\partial f(x)/\partial x)^2 (f(x))^{-1}\,dx$; $G = E_z G_z$ with $G_z = \int ((\partial/\partial x) g(y|x))^2 (g(y|x))^{-1}\,dy$; $G' = E_z G_z'$ with $G_z' = \int ((\partial/\partial x) y'(x|z))^2 (g(x|z))^{-1}\,dx$. The usual assumptions on f and g, which insure that F, G_z, G_z' are finite are made. Since $O = F' = \int ((\partial/\partial x) f'(z))^2 (f'(z))^{-1}\,dz$, it is easily seen that $F + nG = G'$ (Third London Symposium on Information Theory, 1955, p. 18). Furthermore, it is a classical result that $v_z^2 G_z' \geqq 1$. Thus $v^2 = E_z v_z^2 \geqq (E_z 1/v_z^2)^{-1} \geqq (E_z G_z')^{-1} = (F+nG)^{-1}$, which is the desired inequality that tends to the usual form when n goes to infinity. It reduces to an equality if and only if $v^2 = v_z^2 = (G_z')^{-1}$ for all z, that is, if and only if $g'(x|z)$ is gaussian with variance independent of z. If, furthermore, $y - x = t$ has a distribution $h(t)$ independent of x, this implies that $f(x)$ and $h(t)$ are also gaussian. (This work was supported in part by the Army (Signal Corps), the Air Force (Office of Scientific Research, Air Research and Development Command), and the Navy (Office of Naval Research).) (Received November 5, 1956.)

Theorem 1 (Schützenberger's Inequality (BCRB)). *Let $X|\Theta$ be a regular Bayesian statistical model. The quadratic (mean-squared error) risk $\mathbf{R} \triangleq \mathbb{E}_{x,\theta}\{(\hat{\theta}(X)-\theta)(\hat{\theta}(X)-\theta)^t\}$ is lower bounded (in Loewner order's sense) by the inverse of the joint Fisher information matrix $\mathbf{J} \triangleq \mathbb{E}_{x,\theta}\{\nabla \log p(X,\theta) \nabla^t \log p(X,\theta)\}$:*

$$\boxed{\mathbf{R} \geq \mathbf{J}^{-1}}$$

Proof. It is well known that the quadratic (mean-squared error) risk is minimized for the MMSE estimator, given by the mean of the posterior distribuition $\hat{\theta}^*(x) = \mathbb{E}(\theta|x)$. Therefore, it suffices to prove the inequality on the minimal risk $\min \mathbf{R} = \mathbb{E}_x \operatorname{Cov}(\theta|x)$, where $\operatorname{Cov}(\theta|x) = \mathbb{E}_{\theta|x}\{(\theta - \mathbb{E}(\theta|x))(\theta - \mathbb{E}(\theta|x))^t\}$ is the covariance matrix of the *posterior*. The (matrix) Weyl-Heisenberg inequality (a.k.a. uncertainty principle) $\mathbf{R}_{t\cdot f} \geq \frac{1}{4}\mathbf{R}_{\nabla f}^{-1}$ applied to the function $f(\theta) = \sqrt{p(\theta|x)}$ for fixed x, reads, after making a change of variable $\theta \leftarrow \theta - \mathbb{E}(\theta|x)$, $\operatorname{Cov}(\theta|x) \geq \frac{1}{4}\mathbf{R}_{\nabla\sqrt{p(\theta|x)}}^{-1}$. Now since $\nabla\sqrt{p(\theta|x)} = \frac{1}{2\sqrt{p(\theta|x)}}\nabla p(\theta|x)$, we have $\mathbf{R}_{\nabla\sqrt{p(\theta|x)}} = \frac{1}{4}\mathbb{E}_{\theta|x}\{\nabla \log p(\theta|x) \nabla^t \log p(\theta|x)\} = \frac{1}{4}\tilde{\mathbf{J}}(x)$, which gives $\operatorname{Cov}(\theta|x) \geq \tilde{\mathbf{J}}(x)^{-1}$ for any fixed data vector x, where the *posterior Fisher information matrix*: $\tilde{\mathbf{J}}(x) \triangleq \mathbb{E}_{\theta|x}\{\nabla \log p(\theta|x) \nabla^t \log p(\theta|x)\}$ satisfies the relation $\mathbf{J} = \mathbb{E}_x \tilde{\mathbf{J}}(x)$, as is easily checked. Taking the expectation over the unconditional law $p(x)$ and applying the operator convexity of the function $A \mapsto A^{-1}$ concludes: $\mathbf{R} \geq \mathbb{E}_x \operatorname{Cov}(\theta|x) \geq \mathbb{E}_x\big(\tilde{\mathbf{J}}(x)^{-1}\big) \geq \big(\mathbb{E}_x\,\tilde{\mathbf{J}}(x)\big)^{-1} = \mathbf{J}^{-1}$.


The 7th international conference on Geometric Science of Information
Honorable Mention
Category: Marvelous Presentation
PRESENTED TO
Vasiliki Liontou
AUTHOR OF THE PAPER
Geometry of Cells Sensible to Curvature and Their Receptive Profiles
GSI 2025
October 29th-31st 2025
Saint-Malo
Frédéric Barbaresco
Thales, France
General co-chair
Frank Nielsen
Sony Computer Science Laboratories, Japan
General co-chair
Alice Barbora Tumpach
CNRS Paul Institute, Austria
Lille University, France
Prize committee, President

Vasiliki Liontou

Vasiliki Liontou is a postdoctoral researcher in the Department of Mathematics at University of Bologna, working under the supervision of Giovanna Citti and Nicola Arcozzi. She earned a PhD in Mathematics from the University of Toronto, supervised by Matilde Marcolli and Boris Khesin, during which her research focused on combining contact geometry and Gabor analysis for models of the primary visual cortex. Her current research uses differential geometry and harmonic analysis to model the interactions between different cell families in the visual cortex.

HONORABLE MENTION
in the category MARVELOUS PRESENTATION

Geometry of Cells Sensible to Curvature and Their Receptive Profiles

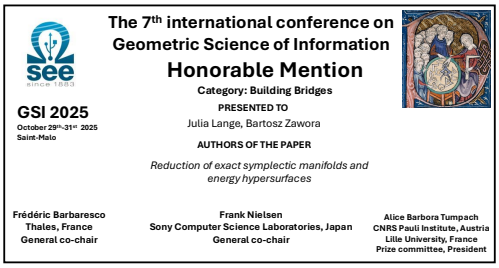
In her very didactical presentation at GSI 25, Vasiliki Liontou proposed a model of the functional architecture of curvature sensitive cells in the visual cortex that associates curvature with scale. Using contact geometry as well as a decomposition coming from an Ehresmann connexion, the tangent bundle to the manifold of unit covectors of the retinal surface is endowed with two splittings which provide an intrinsic description of the organization of the cortex. The feature space of orientation and position is naturally enhanced via its oriented prolongation, yielding a 4-dimensional manifold endowed with a canonical Engel structure, namely a completely non-integrable rank 2 distribution. This structure encodes position, orientation, signed curvature, and scale. Vasiliki Liontou associates an open submanifold of the prolongation with the quasi-regular representation of the similitude group SIM (2), and find left-invariant generators for the Engel structure. Finally, she uses the generators of the Engel structure to characterize curvature-sensitive receptive profiles.

Geometrical Modeling of Curvature Detecting Cells in V_1

Connectivity & Receptive Profiles	Models of Connectivity			Models of Receptive Profiles
	Fiber Bundles		Non-integrable Distributions	Lie Group /Uncertainty Principle
Contrast	$\mathbb{E}^2$ (Euclidean Plane)	Intrinsic Description Propagation Directions	–	$(\mathbb{R}^2, +)$ Translations
Orientation Detectors	$\mathbb{S}^1 \hookrightarrow \mathbb{S}(T^*\mathbb{E}^2)$ (unit covectors)		$H = \ker(a)$ (contact structure)	$SE(2)$ Translations-Rotations
Curvature Detectors	$\mathbb{S}^1 \hookrightarrow \mathbb{P}H$ (Cartan prolongation of H)		$D = \ker(a_1) \cap \ker(a_2)$ (Engel structure)	$SIM(2)$ Translations-Rotations-Scaling of Osculating Circle

We present a model for curvature detecting cells that bridges previous models expressed either in terms of fiber bundles or non-integrable distributions or Lie groups. We provide a unified language for the description of different families of cells their functionality and their interaction. The shape of receptive profiles arises from the uncertainty principle of a Lie group associated to the non-integrable distribution which, in turn, dictates the connectivity within the family. The directions of neural propagation are characterized by the non-integrable distribution and a connection on the fiber bundle. Images in table from "Hubel, David H. (1988). Eye, Brain, and Vision. New York: Scientific American Library."

HONORABLE MENTION
in the category
BUILDING BRIDGES



Reduction of exact symplectic manifolds and the energy hypersurfaces

Julia Lange

Julia Lange is pursuing her PhD at the Department of Mathematical Methods in Physics at the University of Warsaw. Her research focuses on geometric mechanics and mathematical physics. She is currently working on extending the Hamilton–Jacobi theory to different geometric structures, such as twisted Poisson and k-contact ones. She graduated from the University of Warsaw with distinction. Apart from that, she is passionate about figure skating in her free time.

In this article, presented in a highly didactic manner by Bartosz M. Zawora at GSI 25 and written in collaboration with Julia Lange, the authors introduce two reduction procedures for Hamiltonian systems on an exact symplectic manifold admitting Lie group symmetries. The first reduction procedure is a modified Marsden–Meyer–Weinstein reduction theorem for exact symplectic manifolds, and the second is a reduction theorem for contact manifolds given by energy hypersurfaces. After a very careful analysis, the authors were able to show that these reduction procedures are equivalent, leading to a diffeomorphism of the reduced spaces and connecting symplectic and contact reductions. Each approach presented in the article is illustrated with an example.

Theorem. *Let (S,η) be an energy hypersurface associated with a G-invariant exact symplectic Hamiltonian system (P,θ,∇,h). Let $\mathbf{J}_\eta^{\Phi^S}\colon S\to\mathfrak{g}^*$ be a contact momentum map related to contact Lie group action $\Phi^S\colon G\times S\to S$ induced by an exact symplectic momentum map $\mathbf{J}_\theta^{\Phi}\colon P\to\mathfrak{g}^*$ related to an exact symplectic Lie group action $\Phi\colon G\times P\to P$ that is quotientable on $(\mathbf{J}_\theta^{\Phi})^{-1}(\mathbb{R}^\times\mu)$ by $K_{[\mu]}$. In addition, assume that $\mu\in\mathfrak{g}^*$ is a regular value of $\mathbf{J}_\eta^{\Phi^S}$ and $\mathbf{J}_\theta^{\Phi}$. Define $\kappa\colon S_{[\mu]}\to M_{[\mu]}$ as $i_{M_{[\mu]}}\circ\kappa=\jmath$. Then, κ is a diffeomorphism.*

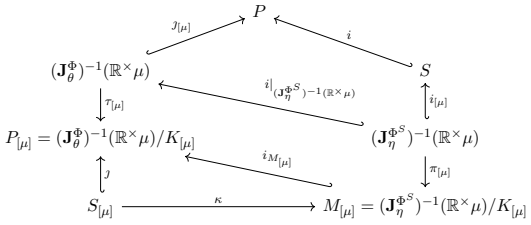
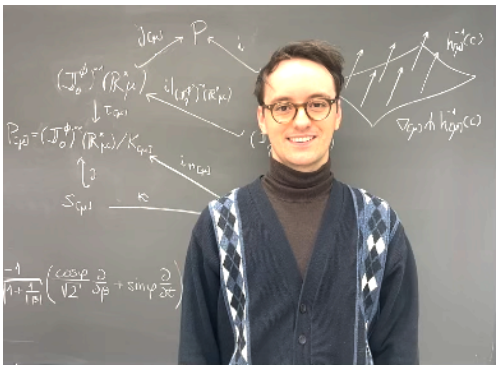


Figure 1: Diagram illustrating the reduction scheme of energy hypersurfaces.

Bartosz M. Zawora

Bartosz M. Zawora is a PhD student at the Department of Mathematical Methods in Physics of the University of Warsaw. His research is focused on the extensions of the Marsden–Meyer–Weinstein reduction and its application to the stability of Hamiltonian systems and hydrodynamic equations. He has visited leading research centres in Canada, Spain and USA. He has also actively participated in numerous international conferences and research projects. He graduated with distinction from the University of Warsaw, receiving the award for the best master's thesis at the Faculty of Physics in 2021 and got a distinction for his teaching duties in 2022. Beyond his academic work, he enjoys sailing on the open seas.



SELECTED PAPERS GSI 2025

A probabilistic view on Riemannian machine learning models for SPD matrices
Thibault de Surrel, Florian Yger, Fabien Lotte, Sylvain Chevallier

A Geometric Deep Learning Approach to Forecast the Time Series of Covariance Matrices
Michele Palma, Andrea Bucci

Minimum of Divergences with Relaxation: a Hilbertian Alternative to Duality Approach
Valérie Girardin, Pierre Maréchal

Global Positioning on Earth
Mireille Boutin, Rob Eggermont, Gregor Kemper

Learning Riemannian Metrics for Interpolating Animations
Sarah Kushner, Vismay Modi, Nina Miolane

Maximum likelihood estimation for the λ-exponential family
Xiwei Tian, Ting-Kam Leonard Wong, Jiaowen Yang, Jun Zhang, Sarah Kushner, Vismay Modi, Nina Miolane

Torsion of alpha-connections on the density manifold
Lorenz Schwachhöfer

Log-Euclidean Frameworks for Smooth Brain Connectivity Trajectories
Olivier Bisson, Xavier Pennec, Yanis Aeschlimann, Samuel Deslauriers-Gauthier

Universal kernels via harmonic analysis on Riemannian symmetric spaces
Cyrus Mostajeran, Franziskus Steinert, Salem Said

Orientation Scores should be a Piece of Cake
Finn Sherry, Chase van de Geijn, Erik Bekkers, Remco Duits

On Invariant Conjugate Symmetric Statistical Structures on the Space of Zero-Mean Multivariate Normal Distributions
Hikozo Kobayashi, Takayuki Okuda

Confidence Bands for Multiparameter Persistence Landscapes
Ines Garcia-Redondo, Anthea Monod, Qiquan Wang

Universal Collection of Euclidean Invariants between Pairs of Position-Orientations
Gijs Bellaard, Bart M. N. Smets, Remco Duits

Note on harmonic exponential families on homogeneous spaces
Koichi Tojo, Taro Yoshino

Information Geometry on the l^2-Simplex via the q-Root Transform
Levin Maier

Geodesic flow of a statistical manifold associated to Souriau's thermodynamics
Jérémie Pierard de Maujouy, Daisuke Tarama

Intrinsic LDA for 3D Shape Classification via Parallel Transport
Maria Victoria Ibáñez-Gual, Jorge Valero-Zorraquino, Amelia Simó, Vicent Gimeno i Garcia

Geometry of Cells Sensible to Curvature and Their Receptive Profiles
Vasiliki Liontou

Eigengap Sparsity for Covariance Parsimony
Tom Szwagier, Guillaume Olikier, Xavier Pennec

Statistical models built on sub-exponential random variables
Barbara Trivellato, Paola Siri

A Historical Perspective on the Schützenberger-van~Trees Inequality: A Posterior Uncertainty Principle
Olivier Rioul

A new symmetry group for Physics to revisit the Kaluza-Klein theory
Géry de Saxcé

Tree inference with varifold distances
Elodie Maignant, Tim Conrad, Christoph von Tycowicz

Lie-Adaptive Inversion of Signature via Pfeffer-Seigal-Sturmfels Algorithm
Remi Vaucher

Reduction of exact symplectic manifolds and energy hypersurfaces
Julia Lange, Bartosz M. Zawora

LAST WORDS FROM THE PRIZE COMMITTEE PRESIDENT

Excellent or well-endowed with resources?

Alice Barbora Tumpach

is a Research Director at Wolfgang Pauli Institute (WPI) and the deputy head of the Mathematical Artificial Intelligence and Machine Learning Research Division of WPI. She is an Expert in Infinite-Dimensional Geometry, her expertise ranging from Symplectic and Poisson geometry, integrable systems, Kähler and hyperkähler Geometry, Functional Analysis and applications of infinite-dimensional Geometry to Computer Vision and Pattern Recognition. She is currently leading the Geometry-Informed Machine Learning Group and PI of FWF Project PAT 1179524 ``Geometric Green Learning on Groups and Quotients spaces'' (420 887 EUR) and FWF Mozart Project I-5015N ``Banach Poisson-Lie Groups and integrable systems''(306 768 EUR). She has been Maître de Conférence at Lille University since 2007 in the Department of Mathematical Physics, currently on leave from this position. She has also a solid training in Diversity Management and Gender Studies with a certification from TU University, Vienna.

Our ability to conduct research depends mainly on the resources we have at our disposition. These resources are diverse: financial stability, time, computers, the ability to travel, emotional strength, resilience, the ability to concentrate, or a low mental load to name a few. In the publication ``Bridging Neurodiversity and Open Scholarship: How Shared Values Can Guide Best Practices for Research Integrity, Social Justice, and Principled Education'', the authors introduce the Wheel of Academic Privileges (see picture), the analogue of the Wheel of Power, Privilege, and Marginalization, by Sylvia Duckworth, whose origin can be traced back to the Canadian Council of Refugees (CCR). It shows the different dimensions that play a role in our university life, obstacles for some of us, privileges for others. In this context, what does the term "excellence," so often used by many institutions, really mean?

Wheel of Academic Privileges

La vérité sort de la bouche des enfants...

La seule personne à laquelle il est fait sens de me comparer, c'est celle que j'étais hier.

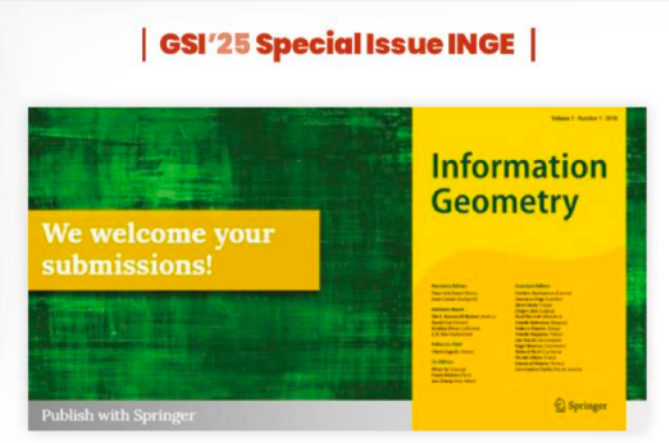
Héloïse Guéritaud, 2023

LAST WORDS OF THE PRIZE COMMITTEE PRESIDENT

A conference is usually a wonderful experience for most of the participants, thanks to the friendly atmosphere and the sharing of common topics of reflection. However, this is not the case for everyone. It can even be said that in all conferences there are always interactions that are strained, where one of the participants abuses the power they think they have and tries to put their counterpart in an uncomfortable position, often in a subtle way (scientists are intelligent people). We can, of course, try to blame the people who interact, but most of the time they are very nice people. What produces this kind of interaction is cultural; it comes from the culture that prevails in the academic world. It is currently common to allow oneself to step outside the boundaries of respect and to show one's power and authority. In order to initiate a cultural change in the academic world, we would like to remind you of the basic rules of fruitful and constructive interactions that you can memorize through the word S.M.A.R.T. GSI strives for SMART values!

S.M.A.R.T. Research Environment

- S- Supportive
- M- Meaningful
- A- Acknowledging the work done
- R- Respectful
- T- Tolerant



Last be not least, let me remind you that a special issue of Information Geometry (INGE) will include selected refereed papers presented at the 7th international conference on Geometric Science of Information (GSI'25) held in Saint-Malo, France, from 28th to 31st October 2025. Submit your extended paper now!

Alice Barbora Tumpach