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Editorial

Preface of the 41st International Workshop on Bayesian Inference and Maximum Entropy Methods in Science and Engineering

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The forty-first International Conference on Bayesian and Maximum Entropy methods in Science and Engineering (41st MaxEnt'22) was held in Institut Henri Poincaré (IHP), Paris, 18–22 July 2022 (<https://maxent22.see.asso.fr/>). Due to the COVID-19 situation, the conference facilitated both the in-person and remote attendance of participants.

This conference continued a long series of MaxEnt events which originally begun at the University of Wyoming (USA) in 1981, with the sixth one organized in France (1992, 2000, 2006, 2010, 2014, and 2022), and the second one organized by SEE in France (SEE MaxEnt'14 in Le Clos Lucé in Amboise: <https://web2.see.asso.fr/en/maxent14>).

Since its creation in 1928, the IHP has taken an interest in all the disciplinary fields, especially at the interface between mathematics and theoretical physics. The Henri Poincaré Institute was inaugurated on 17 November 1928. This institute is organized around two missions: a teaching mission with the Chairs of Probability and Mathematical Physics and Physical Theory and a research mission with the invitation of French and foreign scientists to give lectures in the field of physics and mathematics. Thanks to these two missions, a small group of mathematicians (Emile Borel, Maurice Fréchet, and Georges Darmois) used this institute to create a scientific field dedicated to the theory of probability in Paris. At the same time, they used this institute to acquire a remarkable place on the international probabilistic scene. First lectures at IHP were given by Emile Borel, Maurice Fréchet, and Léon Brillouin on probability. In 1928, Institut Henri Poincaré was created at the University of Paris, specifically to develop the teaching of probability, under the direction of Émile Borel. Maurice Fréchet was appointed lecturer in probability on 1 November 1928 and professor without chair on 19 December. During the 1930s, Institut Henri Poincaré became a magnet for those who wanted to study the probabilities around the personalities of Maurice Fréchet and Georges Darmois. On 1 October 1941, Maurice Fréchet succeeded Émile Borel in the chair of probability calculation and mathematical physics until his retirement in 1949. He was the director of the calculation and statistics laboratories of Institut Henri Poincaré.

The MaxEnt events provided an opportunity to meet and exchange ideas on topics relating to maximum entropy methods and Bayesian methods. MaxEnt 2022 strived to present Bayesian inference and maximum entropy methods in data analysis, information processing, and inverse problems from a broad range of diverse disciplines, including astronomy and astrophysics, geophysics, medical imaging, molecular imaging and genomics, non-destructive evaluation, particle and quantum physics, physical and chemical measurement techniques, economics, and econometrics. This year, special interest will be given to the geometric structures of heat, information, and entropy.

With more than 100 participants (Figure 1), MaxEnt'22 included 6 keynote speakers, 1 guest speaker, 12 invited speakers, 52 talks in oral sessions, and 18 posters in one poster session, with 37% of papers from France, 18% from Germany, 18% from the USA, 15% from the UK, 9% from Japan, 6% from Austria, 6% from Argentina, and 5% from Italy.



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Figure 1. Participants of MaxEnt'22.

The following six tutorials were given at MaxEnt'22:

- Ali Mohammad-Djafari (CNRS, France)—Bayesian and Machine Learning Methods for Inverse Problem;
- Kevin H. Knuth (University at Albany, USA)—Why Mathematics Works and Why Physics is Mathematical;
- John Skilling (University of Cambridge, UK)—Foundations;
- Frank Nielsen (Sony CSL, Japan)—Introduction to Information Geometry;
- Frédéric Barbaresco (THALES, France)—Symplectic Theory of Heat and Information based on Souriau Lie Groups Thermodynamics, Coquinot Thermodynamic Dissipative Bracket and Sabourin Transverse Poisson Structures: Applications to Lindblad Equation;
- Ariel Caticha (University at Albany, USA)—Entropic Dynamics and Quantum Measurement.

MaxEnt'22 also organized the following 12 invited keynote talks:

- Anna Simoni (ENSAE, France)—Bayesian Exponentially Tilted Empirical Likelihood to Endogeneity Testing;
- Antoine Bourget (CEA and ENS Paris, France)—The Geometry of Quivers;
- Bobak Toussi Kiani (MIT, USA)—Quantum Algorithms for Group Convolution, Cross-Correlation, and Equivariant Transformations;
- Emtiyaz Khan (RIKEN, Japan)—The Bayesian Learning Rule;
- Fabrizia Guglielmetti (ALMA Regional Center Scientist at European Southern Observatory, Germany)—Bayesian and Machine Learning Methods in the Big Data Era for Astronomical Imaging;
- Livia Partay (University of Warwick, UK)—Nested Sampling for Materials;
- Lorenzo Valzania (LKB: Sorbonne University-ENS-Collège de France, France)—Imaging Behind Scattering Layers;
- Pierre-Henri Wuillemin (Laboratoire d'Informatique de Paris, France)—Learning Continuous High-Dimensional Models using Mutual Information and Copula Bayesian Networks;
- Torsten Ensslin (MPA, Germany)—Theoretical Modeling of Communication Dynamics;
- Will Handley (University of Cambridge, UK)—Bayesian Sparse Reconstruction: a Brute-Force Approach to Astronomical Imaging and Machine Learning;
- Piotr Graczyk (Angers, France)—Graphical Gaussian Models Associated to a Homogeneous Graph with Permutation Symmetries;
- Olivier Rioul (Telecom ParisTech)—What is Randomness? The Interplay between Alpha Entropies, Total Variation, and Guessing.

Finally, Laurent Mazliak (Sorbonne Université, LPSM) gave an invited talk to honor IHP on the history of probability, Borel, and the emergence of probability on the mathematical scene in France.

The main topics that were addressed included:

- The foundations of probability, inference, information, and entropy;
- Bayesian physics, informed thermodynamics, and informed machine learning;
- Information theory and machine learning tools for inverse problems;
- Bayesian and maximum entropy in real-world applications;
- Geometric statistical mechanics/physics and Lie groups;
- Thermodynamics and maximum entropy densities;
- Quantum theory, computation, tomography, and applications.

The proceedings published by MDPI in the *Physical Sciences Forum* selected works presented at the conference and later peer-reviewed by the scientific committee (<https://www.mdpi.com/2673-9984/5/1>). The high-quality papers are all open access. A selection of extended versions of the proceedings papers will be published in a Special Issue of *Entropy* (https://www.mdpi.com/journal/entropy/special_issues/MaxEnt2022).

The conference co-chairs would like to heartily thank Martino Trassinelli (INSP, Institut des NanoSciences de Paris, CNRS Sorbonne Université UMR7588 Paris, France) who took the lead in finalizing these proceedings and connecting the contributing authors with MDPI.

We believe that the depth and scope of the papers presented in this volume attest the importance of the maximum entropy principle and Bayesian methods, and stress the growing diversity of their applications in both theoretical and applied sciences.

We would also like to thank the sponsors (Figure 2) for supporting this event.



Figure 2. MaxEnt'22 sponsors.

It is our great pleasure to announce that the 42nd Conference on Bayesian Inference (MaxEnt'23) will be held in Garching, Munich, Germany, from the 3rd of July to the 7th of July 2023 (<https://www.ipp.mpg.de/maxent2023>).

Conflicts of Interest: The authors declare no conflict of interest.

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