# $(\Omega, \mathcal{F}, P)$ – Tbilisi 2025

# International Conference on Probability Theory and Statistics

**Dedicated to the 80th birthday of**
**Professor Estate V. Khmaladze**

**July 7–11, 2025**
**Tbilisi, Georgia**

## General information

International Conference on Probability Theory and Statistics is dedicated to the 80th birthday of Professor Estate V. Khmaladze. The conference is organised by Ivane Javakhishvili Tbilisi State University. The conference takes place in Tbilisi, Georgia, on July 7–11, 2025.

Lectures are held at I. Javakhishvili Tbilisi State University, Building 1, 1 Ilia Chavchavadze Ave. (July 7-8) and Sevsamora Hotel in Saguramo (July 10-11).

Immediately after the conference, on July 12–13, 2025, there will be a follow-up workshop in Saguramo.

### Topics

Topics of the conference include, but are not limited to:

- parametric and nonparametric statistics
- probabilistic and statistical problems in high-dimensional spaces
- empirical processes
- theory of distribution-free testing of statistical hypotheses
- analysis of tails in one- and multi-dimensions
- stochastic models in financial and insurance mathematics
- statistical methods in Astronomy
- interactions of geometry and statistics
- occupancy problems and statistical theory of diversity

## Organising and programme committees

### Organising committee

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S. Algeri (University of Minnesota), Aurore Delaigle (University of Melbourne), J.H.J. Einmahl (Tilburg University), I. Gijbels (KU Leuven), S. Gugushvili (Wageningen University & Research), H.L. Koul (Michigan State University), K. Maulik (Indian Statistical Institute), R.M. Mnatsakanov (Chair, West Virginia University), T. Ogihara (University of Tokyo).

## Webpage

For the latest information on the conference see `http://khmaladze-80-tbilisi-2025.tsu.ge/`.

## Sponsors

The conference is financially supported by:

- Faculty of Exact and Natural Sciences of I. Javakhishvili Tbilisi State University
- N. Muskhelishvili Institute of Computational Mathematics of Georgian Technical University
- V. Chavchanidze Institute of Cybernetics of Georgian Technical University
- Georgian American University
- Georgian Statistical Association
- Association of Actuaries and Financial Analysts

## Practical matters

### Lunches

There will be organised lunches for the conference participants in restaurant "Varazi" near the Building 1 of TSU.

### Welcome reception

The welcome reception will be held on July 7, at 18:00–20:00.

### Social programme

The social programme of the conference includes a full-day excursion to Shio-Mgvime–Kvatakhevi on July 9 (departure from Tbilisi at 09:00), and a sightseeing tour of Mtskheta and visiting the winery of Chateau-Mukhrani on July 10.

## Conference dinner

The conference dinner is scheduled on July 9, starting at 19:00 in Sevsamora Hotel.

## Closing and reception

There will be a reception after the closing of the conference on July 11, at 18:00–20:00.

## Catering and transportation in Tbilisi

One can consult online sources, such as `http://wikitravel.org/en/Tbilisi`, for information on catering and public transportation in Tbilisi.

## Questions

Local organisers will be happy to help you with questions of practical nature.

## Schedule

**Monday, July 7**

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|---|---|
| **09:00 - 10:00** | **Registration** |
| **10:00 - 10:30** | **Opening** |
| **10:30 - 11:00** | Jean Bertoin, *On a population model with memory* |
| **11:00 - 11:30** | **Break** |
| **11:30 - 12:00** | Iréne Gijbels, *Measuring dependence between random vectors with application to testing independence* |
| **12:00 - 12:30** | Ursula Müller, *Residual-based inference for semiparametric models* |
| **12:30 - 13:00** | Aurore Delaigle, *Nonparametric density estimation from streaming data* |
| **13:00 - 14:30** | **Lunch** |
| **14:30 - 15:00** | Alexandre Tsybakov, *Conversion theorem and minimax optimality for continuum contextual bandits* |
| **15:00 - 15:30** | Sara Algeri, *When Pearson's chi-square and other divisible statistics are not goodness-of-fits tests* |
| **15:30 - 16:00** | **Break** |
| **16:00 - 16:30** | Vinay Kashyap, *A cornucopia of problems in Astrostatistics* |
| **16:30 - 17:00** | Lydia Brenner (online), *Statistical issues in high energy physics: What we don't know and what we do wrong* |
| **17:00 - 17:30** | John H.J. Einmahl (online), *Accurate estimates of ultimate 100-meter records* |
| **17:30 - 18:00** | Richard Gill (online), *Very small numbers of very rare events* |
| **18:00 - 20:00** | **Reception** |

**Tuesday, July 8**

| | |
|---|---|
| **10:00 - 10:30** | Richard Arnold, *Statistics of ambiguous rotations* |
| **10:30 - 11:00** | Besik Chikvinidze, *The mixed Novikov-Kazamaki type condition for the uniform integrability of the general stochastic exponential* |
| **11:00 - 11:30** | **Break** |
| **11:30 - 12:00** | Erekle Khurodze, *A note on goodness of fit testing for the Poisson distribution* |
| **12:00 - 12:30** | Javier Hidalgo, *Testing for additivity in nonparametric regression models* |
| **12:30 - 13:00** | Chen Zhou, *High dimensional inference for extreme value indices* |
| **13:00 - 14:30** | **Lunch** |
| **14:30 - 15:00** | Petre Babilua, *A Bernstein polynomial approach to estimating Bernoulli regression functions* |
| **15:00 - 15:30** | Saumendu Sundar Mukherjee (online), *LASER: A new method for locally adaptive nonparametric regression* |
| **15:30 - 16:00** | Alexander Ly (online), *Safe anytime-valid e-value Bayes factors for one-factorial ANCOVA–labeling invariance and growth-rate optimality* |
| **16:00 - 18:00** | **Museum visit** |

**Wednesday, July 9**

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|---|---|
| **09:00 - 17:00** | **Excursion to Shio-Mgvime - Kvatakhevi - Saguramo** |
| **19:00 -** | **Conference dinner** |

**Thursday, July 10**

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|---|---|
| **10:00 - 10:30** | Teppei Ogihara, *Efficient drift parameter estimation for ergodic solutions of backward SDEs* |
| **10:30 - 11:00** | Paul Mansanarez, *Edgeworth expansion in a fixed Wiener chaos* |
| **11:00 - 11:30** | **Break** |
| **11:30 - 12:00** | Sami Umut Can, *A novel approach to goodness-of-fit testing for point processes* |
| **12:00 - 12:30** | Hira K. Koul, *A signed-rank estimator in nonlinear regression models when covariates and errors are dependent* |
| **12:30 - 13:00** | Estate Khmaladze, *How to verify that trajectory, observed with errors, is what we think it is; the distribution-free approach* |
| **13:00 - 14:30** | **Lunch** |
| **14:30 - 18:00** | **Sightseeing and wine tour (Chateau-Mukhrani)** |

## Friday, July 11

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|---|---|
| **10:00 - 10:30** | Hiroki Masuda, *Asymptotics for Student-Lévy regression* |
| **10:30 - 11:00** | Farhad Jafari, *Sums of exponentials, moments and mixing* |
| **11:00 - 11:30** | **Break** |
| **11:30 - 12:00** | Sergei Chobanyan, *On the Kolmogorov-Garsia Conjecture* |
| **12:00 - 12:30** | Marina Santacroce, *Asset pricing and interest rates under extreme climate change financial risks* |
| **12:30 - 13:00** | Martin Schweizer, *Dynamic monotone mean-variance portfolio optimization with independent returns* |
| **13:00 - 14:30** | **Lunch** |
| **14:30 - 15:00** | Levan Katsitadze, *On the empirical process of regression* |
| **15:00 - 15:30** | Krishanu Maulik, *Elephant random walk with two memory channels* |
| **15:30 - 16:00** | Jie Yen Fan, *Estimation of rates in general age-and-population-dependent models* |
| **16:00 - 16:30** | **Break** |
| **16:30 - 17:00** | Rafik Aramyan, *Reconstruction of a planar centrally symmetric convex domain by random chord distribution* |
| **17:00 - 17:30** | Robert Mnatsakanov, *Recovering the conditional quantile and regression functions from the product moments* |
| **17:30 - 18:00** | Estate Khmaladze, *TBA* |
| **18:00 - 20:00** | **Closing & reception** |

## Abstracts

**Sara Algeri** (University of Minnesota)

*When Pearson's Chi-square and other divisible statistics are not goodness-of-fit tests*

This talk introduces a unifying approach to the analysis of grouped data, which allows us to study the class of divisible statistics – that includes Pearson's Chi-square, the likelihood ratio as special cases – from a new perspective. Such a study reveals that no single divisible statistic is adequate for goodness-of-fit. It also shows that, in a sparse regime, all tests proposed in the literature are dominated by a class of weighted linear statistics.

**Rafik Aramyan** (Institute of Mathematics of the NAS of Armenia and Russian-Armenian University, Yerevan)

*Reconstruction of a planar centrally symmetric convex domain by random chord distribution*

This work deals with the classical problems of stochastic tomography: obtaining information about a convex body from the distribution of characteristics of its k-dimensional sections. We present a novel approach to reconstructing a planar convex domain from its random oriented chord distribution via recovering the real moments of the domain.

Let D be a convex domain in $\mathbb{R}^2$. We consider the random line $g$ intersecting D with normalized invariant measure. For a random line $g$ intersecting D, by $\overrightarrow{\chi(g)} = (\chi, \varphi)$ we denote the oriented chord $\mathrm{D} \cap g$, the vector specified by direction $\varphi$ (the direction of $g$) and its length $\chi$. Thus we induce the probability distribution in the space of vectors in $\mathbb{R}^2$.

**Definition** The probability distribution of $\overrightarrow{\chi(g)} = \mathrm{D} \cap g$ is called the joint distribution of the oriented random chords of the domain and the corresponding joint cumulative distribution function is denoted by $F_{\overrightarrow{\chi(g)}} = F_{\chi,\varphi}$.

We have the following theorem.

**Theorem 1.** *The distribution of oriented random chords of a planar convex domain D determines D in the class of all convex sets (up to translations and reflections).*

Having Theorem 1, we suggest an algorithm (see [1]) to reconstruct a planar centrally symmetric convex domain D from the joint distribution of the oriented random chords of D by recovering its geometric moments. First, we obtain a relation that allows us to recover the geometric moments of D recursively from the oriented random chord distribution of D. Next, we estimate the geometric moments of D by applying the empirical counterpart of $F_{\chi,\varphi}$. Finally, using the reconstruction algorithms suggested in [2], we reconstruct D.

Such reconstructions are of interest in many areas of mathematics and in problems of nondestructive evaluation in which one wants to find the shape of an object from measurements mainly from a set of data, such as x-ray projections.

This is a joint work with Robert Mnatsakanov and Farhad Jafari.

*References*

[1] R.H. Aramyan et al. Reconstruction of a planar centrally symmetric convex domain by random chord distribution. Lobachevskii J. Math. 45, 5967-5974 (2024).

[2] R.M. Mnatsakanov, R. H. Aramyan, and F. Jafari. Reconstructions of piecewise continuous and discrete functions using moments. J. Math. Sci. (2024).

**Richard Arnold** (Victoria University of Wellington)

*Asymptotic behaviour of inhomogeneous Poisson gaps*

If an object is symmetric, then there are numerous equivalent ways to describe its orientation in space. For example, the lattice of a crystal with cubic symmetry can be mapped onto itself by 24 rotations. The statistics of the orientations of such objects, even exercises as simple as finding the average orientation, are made complicated by these symmetries.
Using examples from seismology and materials science, Richard Arnold will discuss the range of problems that arise when working with such ambiguous orientations. He will present new families of probability distributions and statistical tests associated with these objects.

**Petre Babilua** (Department of Mathematics, Ivane Javakhishvili Tbilisi State University)

*A Bernstein polynomial approach to estimating Bernoulli regression functions*

This paper investigates the nonparametric estimation of the Bernoulli regression function using Bernstein polynomial approximations. A Bernstein-based estimator is proposed for modeling the conditional probability $p(x) = P(Y = 1|x)$ over the interval $[0, 1]$ where $Y$ is a Bernoulli random variable. The consistency and asymptotic normality of the estimator are established under mild smoothness conditions. Confidence intervals for $p(x)$ are constructed, and hypothesis tests are developed to evaluate the form of the regression function and to compare two Bernoulli regression functions. The tests are shown to be consistent and asymptotically strictly unbiased under one-sided alternatives, including Pitman-type alternatives. The approach is particularly notable for its boundary-free behavior, offering advantages over traditional kernel methods. Simulation-based variance estimators are introduced for test statistics, further supporting practical applications in fields such as biostatistics and reliability analysis.

**Jean Bertoin** (Institute of Mathematics, University of Zurich)

*On a population model with memory*

Consider first a memoryless population model described by the usual branching process with a given mean reproduction matrix on a finite space of types. Motivated by the consequences of atavism in Evolutionary Biology, we are interested in a modification of the dynamics where individuals keep full memory of their forebears and procreation involves the reactivation of a gene picked at random on the ancestral lineage. By comparing the spectral radii of the two mean reproduction matrices (with and without memory), we observe that, on average, the model with memory always grows at least as fast as the model without memory. The proof relies on analyzing a biased Markov chain on the space of memories, and the existence of a unique ergodic law is demonstrated through asymptotic coupling.

**Lydia Brenner** (National Institute for Subatomic Physics, Amsterdam)

*Statistical issues in high energy physics: What we don't know and what we do wrong*

In most analyses in high energy physics the datasets are large. This is great for physics and statistics! The simple poisson uncertainties from the size of the dataset are no longer dominant and the statistical inference can truly begin. However, the analysis is done by physicists, not statisticians, and we therefore encounter interesting problems nobody ever knew to study or think about. This talk will showcase some statistical issues we encounter in high energy physics where we do not know what the (statistics) answer is and even show a few places where the analysis went wrong due to physicists doing the statistics wrong.

**Sami Umut Can** (University of Amsterdam)

*A novel approach to goodness-of-fit testing for point processes*

Suppose we are given an observed path from a temporal point process (e.g. deaths in a population) and we would like to test the goodness-of-fit of a particular parametric model for the conditional intensity of the event occurrences. In this paper, we propose a novel approach to conducting such goodness-of-fit tests. The idea is to consider the compensated point process, where the compensator is estimated parametrically, and to transform this process into a Poisson process compensated by its own estimated compensator. Then it is sufficient to know the asymptotic behavior of the latter process to test the goodness-of-fit of a wide class of parametric intensity models. We demonstrate the applicability of our approach through Monte Carlo simulations and data analyses.

**Besik Chikvinidze** (Ivane Javakhishvili Tbilisi State University and Georgian American University)

*The mixed Novikov-Kazamaki type condition for the uniform integrability of the general stochastic exponential*

Let us introduce a stochastic exponential of the local martingale $M$:

$$\mathcal{E}_t(M) = \exp\left\{M_t - \frac{1}{2}\langle M^c\rangle_t\right\} \prod_{0<s\leq t} (1 + \triangle M_s)e^{-\triangle M_s},$$

where $M^c$ denotes continuous martingale part and $\triangle M$ jump of $M$. It is well known that $\mathcal{E}_t(M) = 1 + \int_0^t \mathcal{E}_{s-}(M)dM_s$, so for local martingale $M$ the associated stochastic exponential $\mathcal{E}(M)$ is a local martingale (J. Jacod [2] Proposition (6.5)), but not necessarily a true martingale.

In this paper we generalize the mixed Novikov-Kazamaki condition and introduce a new type sufficient condition using the predictable process $a_s \in [0,1]$ instead of the constant $a \in [0,1)$. Using this type condition Chikvinidze [1] obtained necessary and sufficient conditions for the uniform integrability of the stochastic exponential in case of continuous exponential martingales.

Now we formulate the main result of this paper:

**Theorem 1** Let $M$ be a local martingale with $\triangle M_t > -1$. If there exists some predictable, $M-$integrable process $a_s \in [0,1]$, a constant $\varepsilon \in (0,1)$ and a stopping time $T$ such that

$$\mathrm{D} = \sup_{0\leq\tau\leq T} E\exp\Big\{\int_0^\tau a_s dM_s + \int_0^\tau \Big(\frac{1}{2}-a_s\Big)d\langle M^c\rangle_s + \varepsilon\int_0^\tau 1_{\{1-a_s<\varepsilon\}}d\langle M^c\rangle_s$$

$$+\sum_{0<s\leq\tau}\Big(\ln(1+\triangle M_s) - \frac{\triangle M_s}{1+\triangle M_s} + \ln(1+a_s\triangle M_s) - a_s\triangle M_s\Big)\Big\} < \infty \qquad (1)$$

where *sup* is taken over all stopping times $\tau \leq T$, then the stochastic exponential $\mathcal{E}(M)$ is a uniformly integrable martingale on the stochastic interval $[[0,T]]$.

**Remark** If $M$ is a continuous local martingale and $a_s \equiv a \neq 1$, then our condition turns to the well known mixed Novikov-Kazamaki condition [3].

With this we construct three counterexamples such that for them the Lepingle-Memin's [4] condition fails but conditions of Theorem 1 is satisfied for $a_s \equiv 1$ in the first example and for $a_s \equiv a \in (0,1]$ in the second example. With this in the second counterexample we show that A. Sokol's [6] conditions fail for every $\alpha(a)$ and therefore P. Protter and K. Shimbo's [5] condition also fails. The third counterexample shows us the advantage of using predictable process $a_s$ rather than constant $a$. More precisely, we construct a local martingale such that for any constant $a \in [0,1]$ the condition (1) of Theorem 1 fails (therefore Lepingle-Memin's condition [4] also is not satisfied), but there exists a predictable process $a_s \in [0,1]$ such that conditions of Theorem 1 is satisfied. In all counterexamples the constructed local martingales are purely discontinuous with one jump in the first and second examples and with two jumps in the third example.

*References*

[1] B. Chikvinidze. Necessary and Sufficient Conditions for the Uniform Integrability of the Stochastic Exponential. Journal of Theoretical Probability, doi: https://doi.org/10.1007/s10959-020-01047-4.

[2] J. Jacod. Calcul Stochastique et Problemes de Martingales. Vol. 714 of Lecture Notes in Mathematics, Springer-Verlag, Berlin Heidelberg New York, 1979.

[3] N. Kazamaki. Continuous Exponential Martingales and BMO. Vol. 1579 of Lecture Notes in Mathematics, Springer, Berlin-Heidelberg, 1994.

[4] D. Lepingle and J. Memin, Sur L'integrabilite Uniforme Des Martingales Exponentielles. Zeitschrift fur Wahrscheinlichkeitstheorie und Verwandte Gebiete, 42 (1978), pp. 175-203.

[5] P. Protter and K. Shimbo. No Arbitrage and General Semimartingales. Markov Processes and related Topics: A Festschrift for Thomas G. Kurtz, Vol. 4 (2008), pp. 267-283

[6] A. Sokol. Optimal Novikov-type criteria for local martingales with jumps. Electronic Communications in Probability, Vol. 18 (2013), no. 39, pp. 1-8. doi: 10.1214/ECP.v18-2312, ISSN: 1083-589X

**Sergei Chobanyan** (Muskhelishvili Institute of Computational Mathematics, Georgian Technical University)

*On the Kolmogorov-Garsia Conjecture*

A proof of the following theorem conjectured by Garsia will be discussed: let $(\varphi_1, \ldots, \varphi_n)$, $n \geq 2$ be an orthonormal system in $L_2(\Omega, P)$. Then there exists a rearrangement $\pi : \{1, \ldots, n\} \to \{1, \ldots, n\}$ such that for any scalars $(\alpha_1, \ldots, \alpha_n)$ with $\sum_{i=1}^n |\alpha_i|^2 = 1$ we have:

$$\left( \int_\Omega \max_{1 \leq k \leq n} | \sum_{i=1}^k \alpha_i \varphi_{\pi(i)}(\omega)|^2 P(d\omega) \right)^{\frac{1}{2}} \leq C \, ,$$

where $C$ is an absolute constant.

This theorem implies a positive answer to the Kolmogorov Conjecture which sounds as follows: for a given probability space $(\Omega, P)$ and a given infinite orthonormal sequence $\varphi_n \in L_2(\Omega, P)$, $n = 1, 2, \ldots$ there exists a rearrangement $\pi : \mathbb{N} \to \mathbb{N}$ such that $\varphi_{\pi(n)},$, $n = 1, 2, \ldots$ is a convergence system.

This talk is based on joint considerations with L. Chobanyan, G. Giorgobiani and V. Tarieladze.

**Aurore Delaigle** (University of Melbourne)

*Nonparametric density estimation from streaming data*

We consider nonparametric density estimation from streaming data such as observations collected from sensor networks. Those data are characterized by their continuous collection over time in a high-velocity and often nonstationary environment, requiring near-real-time low-storage processing methods. We study the properties of an iterative estimator, which does not require storing data for long periods of time nor accessing them repeatedly. Then we suggest a procedure for implementing it in practice.

**John H.J. Einmahl** (Tilburg University)

*Accurate estimates of ultimate 100-meter records*

We employ the novel theory of heterogeneous extreme value statistics to accurately estimate the ultimate world records for the 100-m running race, for men and for women. For this aim we collected data from 1991 through 2023 from thousands of top athletes, using multiple fast times per athlete. We consider the left endpoint of the probability distribution of the running times of a top athlete and define the ultimate world record as the minimum, over all top athletes, of all these endpoints. For men we estimate the ultimate world record to be 9.56 seconds. More prudently, employing this heterogeneous extreme value theory we construct an accurate asymptotic 95% lower confidence bound on the ultimate world record of 9.49 seconds, still quite close to the present world record of 9.58. For the women's 100-meter dash our point estimate of the ultimate world record is 10.34 seconds, somewhat lower than the world record of 10.49. The more prudent 95% lower confidence bound on the women's ultimate world record is 10.20.

This is joint work with Yi He (University of Amsterdam).

**Jie Yen Fan** (Monash University)

*Estimation of rates in general age-and-population-dependent models*

We consider general age-and-population-dependent population systems, where individual birth and death rates depend not only on age but also on the overall population composition. These systems can be described by measure-valued stochastic processes. Functional Law of Large Numbers and Central Limit Theorem with large carrying capacity can be established. The estimation of the rates can then be obtained through the LLN and CLT using test functions.

Joint work with Kais Hamza, Fima Klebaner and Ziwen Zhong.

**Irène Gijbels** (Department of Mathematics, KU Leuven)

*Measuring dependence between random vectors with application to testing independence*

In this talk we discuss some approaches to measure dependence between a finite number of random vectors. Approaches that we explored in recent work consists of making use of (i) the concept of $\Phi$-divergences, and of (ii) optimal transport techniques. In this talk we will mainly focus on one of these approaches. We discuss estimation of the dependence measures, and establish the asymptotic distribution of the estimates, both under non-independence and under independence. The limiting distributions, as well as the rates are different under non-independence and under independence. These results are then used to discuss some tests for testing mutual independence of random vectors.

This talk is based on joint work with Steven De Keyser.

**Richard Gill** (Leiden University, Netherlands)

*Very small numbers of very rare events*

In this talk I want first to pay tribute to Estate Khamaladze, who has been a respected colleague and a dear friend for many years.

After some short reminiscences about our first contacts I will talk a little about my current research, which is focussed on the detection, investigation, and prosecution of health care serial killers. Such cases are thankfully very rare but they present special challenges to police and judiciary. They can easily lead to a miscarriage of justice. Statisticians can and should play a big role in them.

A murder investigation usually starts with a clearly murdered person. In the cases which interest us, we start with a statistically anomalous number of deaths on a medical unit where deaths are unfortunately normal. Add to this an obvious correlation between presence of a notable nurse and deaths which were unexpected and hard to explain. Add to this a paranoid doctor who unknown to themselves is making a lot of mistakes, and we have a recipe for disaster.

I will discuss the cases of Lucia de Berk in the Netherlands, and of Lucy Letby in the UK.

**Javier Hidalgo** (London School of Economics and Political Science)

*Testing for additivity in nonparametric regression models*

*Key Words*: Additivity, B-splines, Sieve estimators, Khmaladze's transformation

We describe and examine a test for additivity in a nonparametric framework using partial sums empirical processes. We show that, after a suitable transformation, its asymptotic distribution is a functional of $\mathcal{B}\left(F_x\left(x\right)\right)$, where $\mathcal{B}\left(x\right)$ is the standard Brownian sheet in $\left[0,1\right]^2$ and $F_x\left(x\right)$ is the probability distribution function of $x \in \left[0,1\right]^2$. Although the asymptotic behaviour does not depend on the model or its estimator, it is not pivotal. Due to the latter and the possible poor approximation of the asymptotic critical values to the finite sample ones, we also describe a valid bootstrap algorithm.

**Farhad Jafari** (University of Minnesota)

*Sums of exponentials, moments and mixing*

Sums of real and complex exponentials are ubiquitous in mathematics. Given an arbitrary linear combination of $N$ exponentials,

$$f(t) = \sum_{n=1}^{N} c_n \exp(\lambda_n t),$$

in this presentation, we demonstrate how the unknown parameters $c_n$ and $\lambda_n$ may be obtained from the estimated values of the function $f(t)$ at arbitrary $2N$ points, $t_1, \ldots, t_{2N}$. This result provides an alternative solution to the De Prony problem

(1795), where the latter is based on a finite difference scheme and requires uniform sampling. The solution can also be expressed in terms of the dynamics moments of $f(t)$ on the intervals $[0, t_k]$, $k = 1, \ldots, 2N$. Numerical results demonstrate rapid convergence of this method to the actual parameters, and the sensitivity of the parameter estimations to sub-optimal estimates of $f(t)$ will be shown.

Applications of these results to compartmental modeling, theory of finite mixtures and Laplace transform inversions will be discussed.

**Vinay Kashyap** (Center for Astrophysics, Harvard & Smithsonian)

*A cornucopia of problems in Astrostatistics*

I will discuss several challenges that arise in astronomy for which only imperfect solutions have been devised thus far. These range from the extremely common task of computing enclosed counts fractions in the presence of background, to computing goodness of a model fit for Poisson data, to determining the boundary of an object, to find matches across catalogs, to detect features and change points in multi-D datasets, to the mathematically ill-posed problem of inferring the thermal, compositional, and density structure of stellar coronae from observed spectral lines. I will describe some of the progress the CHASC AstroStatistics Collaboration has made towards solving such problems, and pose them in more detail here.

**Levan Katsitadze** (Department of Mathematics, Ivane Javakhishvili Tbilisi State University)

*On the empirical process of regression*

In regression problems, an approach based on appropriate empirical processes is as important as in classical hypothesis testing problems. Empirical regression processes can be constructed in various ways. Their properties may turn out to depend not on the regression model but on the distribution of errors, which should have a secondary effect.

We show how significant this relationship is and how the power of statistical tests based on different processes can differ in distinguishing between seemingly identical regression models.

**Estate Khmaladze** (Victoria Universoty of Wellington)

*How to verify that trajectory, observed with errors, is what we think it is; the distribution-free approach*

Eventually we would want to come to the problem of testing that the Markov diffusion process we observe satisfies the differential equation $dX(t) = a(X_t, t, \theta)dt + dw_t$ where the shift coefficient depends on the finite-dimensional parameter $\theta$ with unspecified/unknown value. We would want to develop the way this model can be tested with distribution of test statistic, independent from the form of $a(\cdot)$, i.e. with the same distribution for lots of different parametric choices of the shift coefficient.

However, in today's talk we present the approach to this problem for deterministic shift of the form $a(t,\theta)$. As an illustration we will show that testing

$$dX(t) = [\theta_0 a_0(t) + \theta_1 a_1(t)]\,dt + dw_t \quad \text{or} \quad dX(t) = [\theta_0 + \theta_1 t]\,dt + dw_t$$

are not two similar problems, but the *same* problem: one can be mapped into another in one-to-one manner by some unitary operator.

**Erekle Khurodze** (V. Chavchanidze Institute of Cybernetics, Georgian Technical University)

*A note on goodness of fit testing for the Poisson distribution*

Since its introduction in 1950, Fisher's dispersion test has become a standard means of deciding whether or not count data follow the Poisson distribution. The test is based on a characteristic property of the Poisson distribution, and discriminates well between the Poisson and the natural alternative hypotheses of binomial and negative binomial distributions.
While the test is commonly used to test for general deviations from Poissonity, its performance against more general alternatives has not been widely investigated. We present realistic alternative hypotheses for which general goodness of fit tests perform much better than the Fisher dispersion test.

**Hira L. Koul** (Michigan State University)

*A signed-rank estimator in nonlinear regression models when covariates and errors are dependent*

This talk will first discuss asymptotic relative efficiency (ARE) of a signed rank estimator in an errors in variables linear regression model with known Gaussian distributions of the measurement error, the predicting covariate and its surrogate. The ARE of this estimator relative to the bias corrected least squares estimator at a Gaussian regression error distribution is shown to increase to infinity as the measurement error variance increases to infinity. Given this motivation, we then derive asymptotic normality of this signed rank estimator in a class of nonlinear semi-parametric regression models where the predicting random covariate vector is possibly dependent on the regression error and where the regression error distribution need not be known.

Joint work with Palaniappan Vellaisamy.

**Alexander Ly** (Centrum Wiskunde & Informatica, University of Amsterdam)

*Safe anytime-valid e-value Bayes factors for one-factorial ANCOVA-labeling invariance and growth-rate optimality*

We examine the K-sample means problem while accounting for the effects of covariates. Our inference focuses on (1) testing the null hypothesis that all K samples share an identical but unknown mean and (2) providing simultaneous uncertainty quantification for the K-1 average treatment effects. We show how a specific class of Bayes factor naturally emerges in this problem, when the objective is to develop a methodology that ensures explicit exact frequentist control over type I error and coverage rates regardless of how, or even if, data collection is stopped.

Joint work with Udo Boehm, Wouter Koolen, and Peter Grunwald.

**Paul Mananarez** (Université libre de Bruxelles)

*Edgeworth expansion in a fixed Wiener chaos*

We investigate the Edgeworth development for functionals of a Gaussian field. For an element of the p-th Wiener chaos, we derive bounds in the total variation distance between the distribution of F and the so-called Edgeworth development of F: a modified Gaussian measure. The bounds depend only on p and the variance of the carré-du-champ operator of F.

This is a joint work with Guillaume Poly and Yvik Swan.

**Hiroki Masuda** (The University of Tokyo)

*Asymptotics for Student-Lévy regression*

**Objective**
We consider parametric inference for a class of continuous-time linear regression models driven by a Student-$t$ Lévy process: suppose that we have a discrete-time sample $\{(X_{t_j}, Y_{t_j})\}_{j=0}^{[nT_n]}$ with $t_j = j/n$ from the continuous-time regression model

$$Y_t = X_t \cdot \mu + \sigma J_t$$

for $t \in [0, T_n]$, where $X = (X_t)$ is a cádlág stochastic covariate process in $\mathbb{R}^q$ satisfying some regularity conditions, and $J = (J_t)$ is a Lévy process such that the distribution of $J_1$ has the (scaled) Student-$t$ density

$$f(x; \nu) := \frac{\Gamma(\frac{\nu+1}{2})}{\sqrt{\pi}\Gamma(\frac{\nu}{2})}(1 + x^2)^{-(\nu+1)/2}, \qquad x \in \mathbb{R}.$$

Our statistical model is indexed by the unknown parameter

$$\theta := (\mu, \sigma, \nu) \in \mathbb{R}^q \times (0, \infty) \times (0, \infty).$$

We want to estimate the true value $\theta_0 = (\mu_0, \sigma_0, \nu_0)$ of $\theta$ when $T_n \to \infty$ for $n \to \infty$. Then, how can we construct an easy-to-compute and reasonably well-behaving estimator $\hat{\theta}_n = (\hat{\mu}_n, \hat{\sigma}_n, \hat{\nu}_n)$?

At first glance, this may seem like a standard parametric inference problem, but there is a mess. The bottleneck in the analysis is that the Student-$t$ distribution is not closed under convolution, making the likelihood analysis difficult (virtually impossible) to estimate all the parameters fully based on the high-frequency time scale. To efficiently deal with the intricate nature from both theoretical and computational points of view, we propose a *two-stage* quasi-likelihood analysis based on the fully explicit Cauchy and Student-$t$ quasi-likelihood function. The associated analyses require taking the characteristic of the Student-$t$ noise into account in both local and global ways, that is, in both small-time and long-term ways. The full details are available in the recent publication Masuda et al. (2024).

**Summary of asymptotics**

Although the conditional likelihood given $X$ can be written through a Fourier inversion formula, it is rather intractable. To efficiently deal with that intricate nature from both theoretical and computational points of view, we propose the fully explicit *two-stage* procedure which is essentially based on the important fact that $J$ is locally Cauchy distributed ($h^{-1}J_h \xrightarrow{\mathcal{L}}$ Cauchy as $h \to 0$ in an $L^1$-local sense). Informally, it goes as follows:

- First, we make use of the *Cauchy quasi-likelihood* for estimating $(\mu, \sigma)$;
- Second, we construct the *Student-t quasi-likelihood* based on $f(x;\nu)$ with the unit-period residual sequence to estimate the remaining degrees of freedom.

It turned out that using full data in the first step causes a problem arising from "accumulating" small-time Cauchy approximation, showing the need for appropriate *data thinning*. For both cases, we can derive not only the asymptotic distribution of the estimators, but also their uniform integrability.

**First stage**

We consider the (possibly) partial observations over the part $[0, B_n]$ of the entire period $[0, T_n]$, where $(B_n)$ is a positive sequence such that

$$B_n \le T_n, \qquad \exists \varepsilon', \varepsilon'' \in (0,1) \quad n^{\varepsilon''} \lesssim B_n \lesssim n^{1-\varepsilon'}.$$

Write $N_n = [nB_n]$, $a = (\mu, \sigma)$, $a_0 = (\mu_0, \sigma_0)$ and $\varepsilon_j(a) := \dfrac{\Delta_j Y - \mu \cdot \Delta_j X}{h\sigma}$, where $\Delta_j \xi = \xi_{t_j} - \xi_{t_{j-1}}$. Let $\phi_1(y) := \pi^{-1}(1+y^2)^{-2}$, the standard Cauchy density. Then, we introduce the *Cauchy quasi-(log-)likelihood* conditional on $X$:

$$\mathbb{H}_{1,n}(a) := \sum_{j=1}^{N_n} \log\left\{\frac{1}{h\sigma}\phi_1\left(\frac{\Delta_j Y - \mu \cdot \Delta_j X}{h\sigma}\right)\right\} = C_n - \sum_{j=1}^{N_n}\left\{\log\sigma + \log\left(1 + \varepsilon_j(a)^2\right)\right\},$$

where the term $C_n$ does not depend on $a$. We define the Cauchy quasi-maximum likelihood estimator by any element $\hat{a}_n := (\hat{\mu}_n, \hat{\sigma}_n) \in \underset{a \in \overline{\Theta_\mu \times \Theta_\sigma}}{\operatorname{argmax}} \mathbb{H}_{1,n}(a)$.

**Theorem 2.** *Under appropriate assumptions, we have the asymptotic normality*

$$\hat{u}_{a,n} := \sqrt{N_n}(\hat{a}_n - a_0) \xrightarrow{\mathcal{L}} N\left(0, \operatorname{diag}\left(\frac{1}{2\sigma_0^2} S_0, \frac{1}{2\sigma_0^2}\right)^{-1}\right)$$

*and for every $K > 0$ the sequence $\{|\hat{u}_{a,n}|^K\}_n$ is uniform integrable.*

**Second stage**

Suppose additionally that "$T_n$ does not grow rapidly" in the sense that

$$\frac{T_n}{N_n} = \frac{T_n}{[nB_n]} \to 0.$$

Define the *unit-time residual* sequence $\hat{\epsilon}_i := \hat{\sigma}_n^{-1}\left(Y_i - Y_{i-1} - \hat{\mu}_n \cdot (X_i - X_{i-1})\right)$ for $i = 1, \dots, [T_n]$. Let $\varepsilon_i := J_i - J_{i-1}$, so that $\varepsilon_1, \varepsilon_2, \dots \sim$ i.i.d. $t_\nu$. We will estimate $\nu$ based on the maximum-likelihood function as if $\hat{\epsilon}_1, \dots, \hat{\epsilon}_{[T_n]}$ are observed $t_\nu$-i.i.d. samples: we consider the *Student quasi-likelihood* $\mathbb{H}_{2,n}(\nu) := \sum_{i=1}^{[T_n]} \log f(\hat{\epsilon}_i; \nu)$, which is a.s. convex on $(0, \infty)$:

$$\mathbb{H}_{2,n}(\nu) = \sum_{i=1}^{[T_n]} \left( -\frac{1}{2}\log\pi + \log\Gamma\left(\frac{\nu+1}{2}\right) - \log\Gamma\left(\frac{\nu}{2}\right) - \frac{\nu+1}{2}\log\left(1 + \hat{\epsilon}_i^2\right) \right).$$

Then, we define the Student-$t$ quasi-likelihood estimator ($t$-QMLE for short) of $\nu$ by any element $\hat{\nu}_n \in \underset{\nu \in \overline{\Theta}_\nu}{\operatorname{argmax}} \mathbb{H}_{2,n}(\nu)$.

The next result shows that we can estimate $\nu_0$ as if we directly observe $(\varepsilon_i)$.

**Theorem 3.** *Under appropriate assumptions, we have the asymptotic normality:*

$$\hat{u}_{\nu,n} := \sqrt{T_n}(\hat{\nu}_n - \nu_0) \xrightarrow{\mathcal{L}} N\left(0, \left\{\frac{1}{4}\left(\psi_1\left(\frac{\nu_0}{2}\right) - \psi_1\left(\frac{\nu_0+1}{2}\right)\right)\right\}^{-1}\right)$$

*and for every $K > 0$ the sequence $\{|\hat{u}_{\nu,n}|^K\}_n$ is uniform integrable.*

**Related remarks**

- We can modify the main result to handle a sample $(Y_{t_j})_{j=0}^{[nT_n]}$ from an ergodic solution to the Markov process ($Y_0 = 0$) described by

$$Y_t = \mu \cdot \int_0^t b(Y_s)ds + \sigma J_t,$$

  where $\nu_0 > 2$ and $b : \mathbb{R} \to \mathbb{R}^q$ is a known measurable function; the corresponding $X$ in this case is the Riemann approximation of $\int_0^\cdot b(Y_s)ds$. It is possible to derive the asymptotic normality through a slightly modified version of our estimation procedure.

- It is also possible to extend the asymptotic results to a class of locally $\beta$-stable regression models based on a non-Gaussian stable quasi-likelihood, where $\beta < 2$ is the unknown activity index. (An ongoing work with Lorenzo Mercuri)

**Krishanu Maulik** (Indian Statistical Institute)

*Elephant random walk with two memory channels*

Random processes with strong memory arise naturally in various disciplines including physics, economics, biology, geology, etc. Elephant random walk was introduced by Schutz and Trimper (2004) to study the effect of memory on random walks. It is a special type of random walk that incorporates the information of one randomly chosen past step to determine the future step. It has drawn attention of the Statistical Physics literature as it exhibits superdiffusive growth due to the effect of self-excitation. However, memory of a process can be multifaceted and can arise due to interactions of more than one underlying phenomena. Towards this, Random Walk with $k$ Memory Channels was introduced by Saha (2022), where the information of $k$ randomly chosen past steps is needed to decide the future step. The aforementioned work carried out heuristic calculations of variance, and conjectured phase transitions from diffusive to superdiffusive and from superdiffusive to ballistic regimes in the $k = 2$ case. We have proved these conjectures rigorously (with mild corrections), and discovered a new regime at one of the transition boundaries. In this talk, we shall present these results along with a detailed analysis of the asymptotic behaviour of the walk at different regimes.

This talk is based on a joint work with Parthanil Roy and Tamojit Sadhukhan.

**Robert Mnatsakanov** (West Virginia University)

*Recovering the conditional quantile and regression functions from the product moments*

In this talk the problems of estimating the conditional quantile and regression functions given the knowledge of so-called transformed moments are studied. Proposed construction is also applied to the problem of estimating the joint density function of the random coefficients in a linear regression model. Under assumptions that coefficients of the regression function are non-negative random variables, the moment-based procedure for estimating the unknown distribution function of coefficients is proposed.

It is known that in such models application of the estimated conditional characteristic function combined with the regularized Fourier transform inversion provides the consistent estimate of the bivariate density function of random coefficients. Our approach is based on using the Central Slice Theorem applied to corresponding values of the conditional Laplace transform. Note that under proposed construction the regularization technique is not required.

**Soumendu Sundar Mukherjee** (Indian Statistical Institute, Kolkata)

*LASER: A new method for locally adaptive nonparametric regression*

In this talk, we shall focus on the fundamental statistical problem of nonparametric regression and introduce a new method called LASER (abbreviation for Locally

Adaptive Smoothing Estimator for Regression). LASER performs variable bandwidth local polynomial regression and adapts (near-)optimally to the local Hölder exponent of the underlying regression function simultaneously at all points in its domain. It features a single global tuning parameter, with an optimal choice ensuring the above-mentioned local adaptivity. In practice, LASER can be effectively tuned via cross-validation and has excellent performance in comparison with existing nonparametric regression techniques.

This talk will be based on joint work with Sabyasachi Chatterjee (University of Illinois Urbana-Champaign) and Subhajit Goswami (Tata Institute of Fundamental Research).

**Ursula U. Müller** (Texas A&M University and Otto-von-Guericke-Universitat Magdeburg)

*Residual-based inference for semiparametric models*

I will give a brief overview of some joint research on estimating the error distribution in semiparametric models, with emphasis on regression models with independent errors and covariates. This work started with a paper on efficient estimation of the error variance and other expectations of the error distribution in nonparametric regression (J. Statist. Plann. Inference, 2004). Several papers followed on estimating the error distribution in various semiparametric regression models. In most models a simple uniform expansion of the residual-based empirical distribution function can be derived if suitable estimators of the regression function are used to form the residuals. The expansion also characterizes efficient estimators of the error distribution function and provides the basis for distribution free martingale transform tests about the error distribution, as proposed by Khmaladze and Koul (Ann. Statist., 2009).

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**Teppei Ogihara** (The University of Tokyo)

*Efficient drift parameter estimation for ergodic solutions of backward SDEs*

We study parameter estimation for an $m$-dimensional SDE

$$Y_t = Y_0 + \int_0^t \psi(X_s, Y_s, V_s V_s^\top, \theta_0) ds + \int_0^t V_s \, dW_s,$$

where the volatility process $V_t$ is unknown. The focus is on estimating the drift parameter $\theta_0$ in models that naturally arise in finance (e.g., option pricing and portfolio optimization) and stochastic control. The model includes the backward SDE framework where the terminal condition is given, and $V_t$ appears implicitly in the drift. When $V_t$ is specified by a function $b(Y_t, \sigma_0)$ and $\psi(x, y, z, \theta) = a(y, \theta)$, a quasi-log-likelihood function is constructed based on discrete observations $\{Y_{kh_n}\}_{k=0}^n$. For the more challenging case where $V_t$ is unknown and no parametric model is assumed, we estimate $Z_t = V_t V_t^\top$ using local averages:

$$\hat{Z}_l = \frac{1}{c_n h_n} \sum_{m=1}^{c_n} \left( Y_{t^l_m} - Y_{t^l_{m-1}} \right) \left( Y_{t^l_m} - Y_{t^l_{m-1}} \right)^\top,$$

where the sequence $c_n$ is chosen to balance the trade-off between approximation error and the use of previous estimates. A quasi-log-likelihood function $H_n(\theta)$ is then formulated, and the maximum likelihood-type estimator $\hat{\theta}_n$ is defined as the maximizer.

Under suitable regularity, ergodicity, and moment conditions, we show the asymptotic normality of the proposed estimator, and discuss the optimality of the asymptotic variance. A key challenge is the trade-off in choosing $c_n$: while a larger $c_n$ improves the approximation of the integrated volatility, it also increases the error from using a lagged estimator. The method leverages ergodic properties to justify time averaging, which is crucial in establishing asymptotic normality. Compared with earlier approaches, our estimator accommodates drift functions $\psi$ that depend on the unobserved volatility. We simulate a one-dimensional stochastic volatility model to assess the ML-type estimator's accuracy under various tuning parameter settings. The study examines the convergence rate and relative estimation error as sample size increases.

This is a joint work with Mitja Stadje in Ulm University.

**Marina Santacroce** (Catholic University of Milan)

*Asset pricing and interest rates under extreme climate change financial risks*

We develop a dynamic asset pricing framework with brown and green assets. Assets are affected by rare natural disasters linked to climate change and by rare macroeconomic events. Brown assets are furthermore influenced by transition risk. The novelty of the work is to model the clustering nature of the natural disasters introducing self-excited jumps in the dynamics and we show the impact on portfolio composition, risk-free rate, credit spread and asset prices.

**Martin Schweizer** (ETH Zurich, Switzerland)

*Dynamic monotone mean-variance portfolio optimisation with independent returns*

Mean-variance portfolio choice, while popular, has some serious drawbacks: it ca lead to time-inconsistent problems, and it is not monotone. We consider instead its modification to monotone mean-variance (MMV) and want to find a dynamic portfolio strategy which maximises the MMV criterion for final wealth on a finite horizon. Assuming only that the underlying semimartingale asset price model has independent returns, we are able to provide a complete and explicit solution. The only assumption we need is a weak local absence-of-arbitrage condition, and we can show that our results are sharp.

This is based on joint work with Ales Cerny and Johannes Ruf.

**Alexander Tsybakov** (CREST, ENSAE, Institut Polytechnique de Paris)

*Conversion theorem and minimax optimality for continuum contextual bandits*

We study the continuum contextual bandit problem, where the learner sequentially receives a side information vector (a context) and has to choose an action in a convex set, minimizing a function depending on the context. The goal is to find an algorithm minimizing the dynamic contextual regret, which provides a stronger guarantee than the standard static regret. Considering a meta-algorithm that to any input non-contextual bandit algorithm associates an output contextual bandit algorithm, we prove a conversion theorem, which allows one to derive a bound on the contextual regret from the static regret of the input algorithm. We apply this strategy to obtain upper bounds on the contextual regret in several settings (losses that are Lipschitz, convex and Lipschitz, strongly convex and smooth with respect to the action variable). Inspired by the interior point method and employing self-concordant barriers, we propose an algorithm achieving a sub-linear contextual regret for strongly convex and smooth functions in noisy setting. We show that it achieves, up to a logarithmic factor, the minimax optimal rate of the contextual regret as a function of the number of queries.

Joint work with Arya Akhavan, Karim Lounici and Massi Pontil.

**Chen Zhou** (Erasmus University Rotterdam)

*High dimensional inference for extreme value indices*

When applying multivariate extreme value statistics to analyze tail risk in compound events defined by a multivariate random vector, one often assumes that all dimensions share the same extreme value index. While such an assumption can be tested using a Wald-type test, the performance of such a test deteriorates as the dimensionality increases.

This paper introduces a novel test for testing extreme value indices in a high dimensional setting. We show the asymptotic behavior of the test statistic and conduct simulation studies to evaluate its finite sample performance. The proposed test significantly outperforms existing methods in high dimensional scenarios. We apply this test to examine two datasets previously assumed to have identical extreme value indices across all dimensions.

## Participants

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