Bernoulli News

Newsletter of the Bernoulli Society For Mathematical Statistics and Probability

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CONTENTS

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A VIEW FROM THE PRESIDENT

Susan A. Murphy receives the Bernoulli Book from Sara van de Geer during the General Assembly of the Bernoulli Society ISI World Congress in Marrakech, Morocco.

Dear Members of the Bernoulli Society,

It is an honor to assume the role of Bernoulli Society president, particularly because this is a very exciting time to be a statistician or probabilist! As all of us have become, ever-more acutely aware, the role of data in society and in science is dramatically changing. Many new challenges are due to the complex, and vast amounts of, data resulting from the development of new data collection tools such as wearable sensors in clothing, on eyeglasses, in toothbrushes and most commonly on our phones. Indeed there are now wearable radar sensors that provide data that might be used to improve the safety of bicyclists or help visually impaired individuals gain greater independence. There are also wearable respiratory sensors that provide data that could be used to help us investigate the impact of dietary and exercise regimens, or identify nutritional imbalances. There is an increasing need to use complex data such as dynamic data collected from online social networking sites like twitter or facebook to better understand the impact and dynamics of social networks or to further the use of complex metabolomics data from nuclear magnetic resonance spectroscopy/mass spectrometry to develop new treatments.

The high dimensional, complex and often dynamic data that can currently be collected and stored raises exciting challenges for us and our field.

... *Continued on p. 1*

Deadline for the next issue: **31 March, 2018**
Send contributions to: *miguel.decarvalho@ed.ac.uk*

A View from the President (continued from front cover)

Many of our underlying statistical principles, some still in a controversial state, will likely need generalization in this new world. Do we need new estimation principles? How does the concept of efficient estimation generalize to address the current needs to conduct inference with high dimensional, complex data? What role is there for or do we need a generalization of the likelihood principle? Is there a, or what is the, role for hypothesis testing? How does experimental design fit into this new setting? Certainly the dynamic nature of much of this complex, high dimensional data raises interesting challenges for the stochastic processes field. Most importantly how do we utilize this complex data to benefit society?

The Bernoulli Society has a role to play in this changing world. We are sponsoring and supporting meetings such as the 2018 Stochastic Processes and Applications conference to be held in Gothenburg, Sweden, June 11–15 2018. Check out the website at

`http://spa2018.org`

How can we further support our members as they tackle problems such as the above? Do you have ideas about how our Bernoulli Society can better support its' members as they seek to address new statistical and probability challenges? Would you like to be involved in an effort to educate the broader public in probabilistic thinking?

As for new researchers: Do you have ideas about how the Bernoulli Society can support our new researchers as they grow their careers? Our new researchers' receptions have been wildly popular. How can we harness these new researchers' receptions to better engage new researchers and help them? Please think of ways to provide leadership opportunities to our new researchers—feel free to send me ideas (samurphy@fas.harvard.edu)!

I look forward to working with you!

Susan A. Murphy
President of the Bernoulli Society
Cambridge, MA

SPA Gothenburg 2018

News from the Bernoulli Society

Business Meetings at WSC, Marrakech 2017

The General Assembly approved the proposal of two new officers and elected a President-Elect (2017–2019) and six Ordinary Councilors as stated below:

President-Elect (2017–2019):

- Claudia Klüppelberg (Munich, Germany).

Ordinary Councilors (2017–2021):

- Mark Podolskij (Aarhus, Denmark).
- Eulalia Vares (Rio de Janeiro, Brazil).
- Alexander Aue (Davis, USA).
- Ingrid Van Keilegom (Leuven, Belgium).
- Richard Samworth (Cambridge, UK).
- Arnak Dalalyan (Paris, France).

More details on new members, who were not part of the previous 'who is who', will be given later in this issue. Congratulations also to the new elected members of the European Regional Committee of Bernoulli Society:

- Andreas Basse-O'Connor (Aarhus, Denmark).
- Geurt Jongbloed (Delft , Netherlands).
- Peter Kevei (Szeged, Hungary).
- Tatyana Krivobokova (Goettingen, Germany).
- Marloes Maathuis (Zurich, Switzerland).
- Davy Paindaveine (Brussels, Belgium).
- Laura Sangalli (Milan, Italy).
- Ulrike Schneider (Vienna , Austria).

Byeong U. Park
Seoul

Awards and Prizes

Call for Nominations for the 2018 Doeblin Prize

The Bernoulli Society welcomes nominations for the 2018 Wolfgang Doeblin Prize. The Wolfgang Doeblin Prize, which was founded in 2011 and is generously sponsored by Springer, is awarded biannually to a single individual who is in the beginning of his or her mathematical career, for outstanding research in the field of probability theory. The awardee will be invited to submit to the journal *Probability Theory and Related Fields* a paper for publication as the Wolfgang Doeblin Prize Article, and will also be invited to present the Doeblin Prize Lecture at a World Congress of the Bernoulli Society, or at a Conference on Stochastic Processes and their Applications. More information about the Wolfgang Doeblin Prize and past awardees can be viewed at

www.bernoulli-society.org/index.php/prizes

Each nomination should offer a brief but adequate case of support and should be sent by November 15, 2017, to the chair of the prize committee at the following address: Kavita_Ramanan@brown.edu with subject heading: Doeblin Prize 2018.

Kavita Ramanan
Providence

Second Bernoulli Prize for Outstanding Survey Articles in Probability

The paper "Gaussian Multiplicative Chaos and Applications: A Review," by Remi Rhodes (https://goo.gl/WwNeC3) and Vincent Vargas (https://goo.gl/q7zyLh), published in *Probability Surveys* (2014, Vol 11, pp. 315–392) has been awarded the Second Bernoulli Prize for Outstanding Survey Articles in Probability. The prize committee was chaired by Erwin Bolthausen. Combined with Bernoulli Prize for Outstanding Survey Articles in Statistics, the prizes are awarded every two years alternately. The prize in probability was supposed to be awarded at the Bernoulli World Congress, Toronto in 2016, but the decision has been delayed. Information on the prize is to be found at

https://goo.gl/hcBPWQ

Byeong U. Park
Seoul

Samuel Kou: 2018 EMS–BS Joint Lecturer

2018 EMS–BS Joint Lecturer

Samuel Kou (https://goo.gl/sc2N1V) has been chosen as the EMS–BS joint lecturer to speak at the 11th European Conference on Mathematical and Theoretical Biology (ECMTB 2018), to be held in Lisbon, July 23–27, 2018.

More details on this meeting can be found in p. 14 of this issue.

Corina Constantinescu
Liverpool

New Executive Members in the Bernoulli Society

President Elect: Claudia Klüppelberg

Claudia Klüppelberg is full professor at the Center for Mathematical Sciences, Munich University of Technology. She obtained her PhD degree in Mathematics in 1987 from the University of Mannheim. After her Habilitation at the Department of Mathematics at ETH Zurich in 1993 she was professor at the Mathematics Department, University Mainz (1995–97). In Spring 1997 she accepted an offer of the Technische Universität München. Her research interests combine various areas of applied probability and mathematical statistics with applications to ecological, financial and technical risk processes. She published more than 150 articles in scientific journals and co-authored the monograph *Modelling Extremal Events for Insurance and Finance* with Paul Embrechts and Thomas Mikosch, Springer (1997). She is a member of the Editorial Board of the Springer Finance book series, Co-editor of the Springer Lecture Notes in Mathematics Subseries "Levy Matters", as well as Associate Editor of the *Annals of Applied Probability* and the *Scandinavian Journal of Statistics*. Claudia Klüppelberg was Elected IMS Fellow, ISI member, and Chair of the German Stochastics Group. She was Council Member of the Bernoulli Society, Chair of the ERC, and involved in various activities of the Bernoulli Society; in particular, she was Founding Editor of the *Bernoulli News*.

Council Member: Ingrid Van Keilegom

Ingrid Van Keilegom is a professor of statistics at the KU Leuven in Belgium. She gained her PhD in 1998 from Hasselt University, and worked at Penn State University, Eindhoven University of Technology and Université catholique de Louvain before starting in Leuven in 2016. Her research focuses on survival analysis, non- and semiparametric regression, measurement error problems, asymptotic theory, instrumental regression, bootstrap, and their applications. Ingrid is holder of an Advanced ERC grant (2016–2021) focusing on specific problems in survival analysis. She is a fellow of the Institute of Mathematical Statistics (2008), a fellow of the American Statistical Association (2013), and has been co-editor of the *Journal of the Royal Statistical Society*, *Ser*. B (2012–2015).

Council Member: Alexander Aue

Alexander Aue is professor in the Department of Statistics at the University of California, Davis. He obtained a Diplom degree in Mathematics in 2000 from Philipps-University Marburg and a doctorate degree in Applied Mathematics in 2004 from the University of Cologne, both in Germany. His main research interests include structural break analysis, and functional and high-dimensional time series analysis. He is a Fellow of the American Statistical Association and currently serves as Associate Editor for *Journal of the Royal Statistical Society*, *Ser*. B, *Electronic Journal of Statistics*, *Journal of Computational and Graphical Statistics*, *Journal of Business & Economic Statistics* and *Journal of Statistical Planning and Inference*.

Council Member: Arnak Dalalyan

Arnak Dalalyan is a full professor of Statistics at ENSAE ParisTech. He obtained his PhD (2001) from Le Mans University on Statistics for Random Processes. He was a postdoctoral fellow (2002–03) at the Humboldt University of Berlin, an assistant professor (2003–08) at Paris 6 University and a research professor at ENPC (2008–2011). Arnak's research focuses on high dimensional statistics, statistics of diffusion processes and statistical learning theory. Presently, he is an associate editor of *Electronic Journal of Statistics*, *Statistical Inference for Stochastic Processes* and *Journal of the Japan Statistical Society*. Arnak is also regularly serving in the programme committees of machine learning conferences COLT and NIPS.

Council Member: Maria Eulalia Vares

Maria Eulalia Vares is a professor at the Institute of Mathematics, Federal University of Rio de Janeiro. She obtained her Ph.D. in 1980 from the University of California, Berkeley, and immediately joined the Institute of Pure and Applied Mathematics (IMPA), where she worked as a researcher (from assistant in 1981 to full researcher in 1987) during the period 1980-2002. After a period of almost ten years as researcher at the Brazilian Center for Research in Physics (CBPF), she joined the UFRJ at the end of 2011. Her services to the community have been mainly on the editorial side. She served as Associate Editor for a few journals. Editor-in-Chief of *Stochastic Processes and their Applications* in the period 2006–2009, Editor (Theory and Methods) for the *Brazilian Journal of Probability and Statistics* (2013–2014), Editor-in-Chief of the series *Ensaios Matemáticos* (Brazilian Society of Mathematics) since 2004, Editor-in-Chief of the *Annals of Probability* (2015–2017). She has previously served as member of the council of the IMS and as member of the Bernoulli Society council. Chair of the Publications Committee of the Bernoulli Society (2012–2014). She is a member of the Bernoulli Society and of the IMS. Elected Fellow of the IMS in 2011.

Maria's motivation for this new term as council member:

I am glad to serve again as a council member. I feel that the work of the international scientific societies is very important for our community; as council member, my plans are quite modest: I hope to work to promote activities in Latin America and to encourage the participation of women.

Articles and Letters

On Bayesian Inference for Some Statistical Inverse Problems with Partial Differential Equations

Richard Nickl, University of Cambridge
r.nickl@statslab.cam.ac.uk

Communicated by Sara van de Geer

This letter summarizes key ideas from the Ethel Newbold prize lecture. We discuss recent results that provide theoretical support for nonparametric Bayes solutions of statistical inverse problems arising in some partial differential equation model problems of parabolic, elliptic and transport type.

§0. Introduction

Inverse problems form a vast and well-studied area within applied mathematics, statistics and numerical analysis. Just as in other areas of data science, it has become increasingly intractable to understand the real world performance of algorithms designed to solve these problems without considering the effects of *statistical noise*. Often a method that works for noiseless data needs to be substantially modified to deal with the presence of random measurement error. But even when algorithms such as Tikhonov regularisers are shown to be robust to perturbations of the signal via some convergence rate analysis, much is to be gained from interpreting an inverse problem in a genuinely statistical way: First, when applied appropriately, the theory of statistical inference can be used to provide *recovery guarantees* for commonly used algorithms, which in turn permit *uncertainty quantification*, a contemporary word for the statistical practise of reporting confidence regions and the associated process of algorithm-based decision making, such as rejection of scientific hypotheses at a certain significance level. Second, as we shall explain below, a notion of microscopic statistical fluctuations of inverse problem solvers can be introduced, allowing for refined comparisons of the infinitesimal behaviour of competing algorithms. From this a notion of statistical optimality emerges which blends classical 'efficiency ideas' due to C. F. Gauß and R. A. Fisher with analytic questions about the 'information operators' underpinning every inverse problem. In particular Bayesian methods as suggested by Stuart (2010) can be shown to provide optimal solutions for inverse problems in this sense.

§1. Statistical Inverse Problems and PDEs

A large family of important inverse problems arise in the area of partial differential equations (PDEs). Typically some partial differential operator $\mathcal{L}_f$ acting on functions $u : \mathcal{O} \to \mathbb{R}$ defined on some regular bounded domain $\mathcal{O} \subset \mathbb{R}^d$ is given, and the *coefficient* f is the unknown functional parameter of interest. Data is given in the form of some solution u of an operator equation $F(\mathcal{L}_f, u) = 0$ subject to some boundary conditions guaranteeing a solution. Prototypical examples are solutions $u = u_f$ of divergence form elliptic PDEs

$$\mathcal{L}_f u \equiv \nabla \cdot (f_1 \nabla u) - f_0 u = 0 \text{ on } \mathcal{O} \quad \text{s.t. } u = g \text{ on } \partial\mathcal{O} \tag{1}$$

where f_1 models the coefficient of the partial differential operator and f_0 is a potential term. We can treat either f_0 or f_1 as the unknown function f here. Under suitable conditions the map $f \mapsto u_f$ is then injective and we can ask the question of how to infer the value of f given u_f corrupted by additive Gaussian white noise. Applications of such models in engineering and physics are abundant.

We may further introduce some time evolution dynamics on a time interval $[0, T]$, for instance by considering solutions $u(x, t)$ to the parabolic PDE

$$\frac{\partial u(x,t)}{\partial t} - \mathcal{L}_{f,x} u(x,t) = 0 \ \forall (x,t) \in \mathcal{O} \times [0,T], \tag{2}$$

subject to an initial condition $u(\cdot, 0) = g$ and some boundary conditions. Typically here we will discard the potential term in $\mathcal{L}_f$ (i.e., set $f_0 = 0$) and, instead of considering a divergence form operator, explicitly model the 'drift' f_1 and 'diffusion' coefficient f_2 separately; in the scalar case $d = 1$ for instance

$$\mathcal{L}_f(\cdot) = f_1 \frac{d}{dx} + \frac{f_2^2}{2} \frac{d^2}{(dx)^2}.$$

Then u_f is the solution to the heat equation described by the semigroup dynamics with infinitesimal generator $\mathcal{L}_f$. Identifying the functional parameters f_1, f_2

from some observations in such a diffusion model is of fundamental importance in many applications in modern science, e.g., in biology, physics and economics.

Our third example is a first order PDE with boundary data. Consider the transport equation

$$v \cdot \nabla_x u(x,v) + a(x)u(x,v) = f(x),\ x \in \mathcal{O},\ v \in S^{d-1}, \quad (3)$$

subject to the boundary condition $u(x,v) = 0$ for $x \in \partial\mathcal{O}, v \cdot \nu(x) \geq 0$, where $\nu(x)$ is the outer normal at x. Here a is a known attenuation coefficient and f an unknown source function. Along each straight line the last PDE becomes an ordinary differential equation that is easily solved. The influx trace of this solution $u = u_{f,a}(x,v), x \in \partial\mathcal{O}, v \cdot \nu(x) \leq 0$, is precisely the (attenuated) X-ray transform of the source function f, and the inverse problem is to reconstruct f based on this boundary data. When $\mathcal{O}$ is the unit disk and $a = 0$ this equals the standard problem of reconstructing f from its *Radon transform* $\mathcal{R}(f)$, the workhorse of modern 'non-invasive' computerised tomography methods. More generally such X-ray transforms are the basis of many modern scientific imaging methods such as PET and SPECT.

§2. Statistical Noise and Measurement Models

It is natural to assume that physical measurements in inverse problems arise in a statistical fashion. Observations are always discrete, and if we sample the solution u_f of our PDE at a number of 'design points' x_i (such as different geodesics along which a Radon transform is shot), we can model the measurement errors as independent random variables g_i. Each g_i being itself a superposition of many independent random effects, a Gaussian model for the g_i's is approximately correct in view of the central limit theorem. Formally, for our data is then

$$Y_i = u_f(x_i) + g_i, \quad i = 1, \dots, n;\ g_i \overset{\text{iid}}{\sim} N(0,1). \quad (4)$$

By standard arguments from asymptotic statistics (see Reiß (2008) or Chapter 1 in Giné and Nickl (2016)) this discrete measurement model is asymptotically (as $n \to \infty$) equivalent to observing the continuous functional equation

$$Y = u_f + \varepsilon\mathbb{W} \text{ in } \mathbb{H}, \quad \varepsilon = \frac{1}{\sqrt{n}}, \quad (5)$$

where $\mathbb{W}$ is a Gaussian white noise process on the Hilbert space $\mathbb{H}$ that is the natural range of u_f. While $\mathbb{W}$ can be defined by its action on this Hilbert space, it does not define a proper random element in it. For instance in the elliptic case (1), $\mathbb{H} = L^2(\mathcal{O})$ but $\mathbb{W}$ defines a random variable only in a negative Sobolev space $H^{-\beta}, \beta > d/2$. Thus even if u_f is a smooth function, our data Y will be 'rough', and solving for f in the presence of noise with such 'large support' is a non-obvious task.

When considering a time evolution PDE, the additive noise model just described may be relevant too. However, stochastic noise may propagate through the entire system with time, and in this case the theory of stochastic differential equations (SDEs) can come to our aid to provide a consistent measurement model. More precisely, a Markov process $(Y_t : t \geq 0)$ with transition semigroup operator $P_t = e^{t\mathcal{L}_f}, t \geq 0$, provides solutions to the SDE

$$dY_t = f_1(Y_t)dt + f_2(Y_t)dW_t, t \geq 0, \quad (6)$$

with (W_t) a Brownian motion, effectively describing the diffusion of a particle that, when positioned at x at a certain time, has 'infinitesimal' drift $f_1(x)$ with Gaussian noise of variance $f_2^2(x)$. A realistic measurement model for the parabolic PDE (2) then consists of observing the entire trajectory of the Markov process $(Y_t : 0 \leq t \leq T)$ until time T, or of discrete samples $Y_0, Y_\Delta, \dots, Y_{n\Delta}$ thereof, paralleling the situations described in (5), (4) for i.i.d. noise.

§3. The Bayesian Approach

All the above problems share the common structure that we observe

data Y drawn from some distribution P_{u_f}

where u_f is some forward operator and f the unknown function. As suggested in Stuart (2010) (see also Dashti and Stuart (2016)), it is tempting to take the Bayesian approach and model f by some prior probability distribution Π in function space. Even though the models for f from the previous section are typically infinite-dimensional, their near 'Gaussian' character permits the use of basic tools from probability theory to deduce 'Bayes' formula'

$$f \sim \Pi,\ Y|f \sim P_{u_f}\ \Rightarrow f|Y \sim \frac{dP_{u_f}(Y)d\Pi(f)}{\int dP_{u_f}(Y)d\Pi(f)}, \quad (7)$$

where dP_{u_f} is a density with respect to a suitable dominating measure. We can then extract information on f from the posterior distribution $\Pi(\cdot|Y)$ of $f|Y$. For the infinite-dimensional, or 'non-parametric', models relevant here, a large class of priors have been developed in the area of 'Bayesian Nonparametrics', we refer to the recent monograph Ghosal and van der Vaart (2017). While the focus of this letter is not Bayesian *computation*, we note here that modern MCMC methodology can be used successfully to sample from posterior distributions, and to numerically evaluate point estimates of f, such as the posterior mean or mode (see Dashti and Stuart (2016)). The Bayesian approach thus gives concrete algorithms that can be used in real world inverse problems including all the PDE examples introduced above. Moreover, this methodology is attractive for statistical scientists because the spread of the posterior distribution automatically delivers an estimate of the uncertainty in the reconstruction, and hence suggests 'confidence' intervals.

The performance of Bayesian algorithms of course crucially depends on the choice of the prior Π, which in our 'nonparametric' setting serves solely as a regularisation tool and does not represent any subjective beliefs. This can be nicely illustrated by the fact that for linear inverse problems and Gaussian priors Π with associated reproducing kernel Hilbert space $\mathcal{H}$, the posterior mean can be shown to coincide with the usual Tikhonov regulariser which solves

$$\min_f \left[\sum_{i=1}^n (Y_i - u_f(x_i))^2 + \|f\|_{\mathcal{H}}^2 \right], \tag{8}$$

so that the prior choice is somehow dual to the choice of the penalty function in a standard optimisation based estimator for f. For example Matérn or integrated Brownian motion priors will generate regularisers with commonly used penalties arising from standard Sobolev norms.

In light of the previous observation it becomes of crucial importance to study the performance of Bayesian inversion in some 'objective' way that is independent of the prior choice, as otherwise posterior inferences would only be reproducing prior guesses that do not represent anything in particular about the real world. This is not just a 'philosophical' debate about Bayesian or non-Bayesian statistics, but a question of plain common sense, just as the choice of the penalty function $\|\cdot\|_{\mathcal{H}}$ in (8) is not a philosophical question. Trying to understand the 'frequentist' validity of Bayesian inference is a classical topic in mathematical statistics that goes back to Laplace (1812), and which has undergone vigorous development in the last two decades. It can help to provide objective foundations for prior based inference methods also in contemporary inverse problems.

§4. Posterior Contraction Rates to the True Parameter

The posterior distribution $\Pi(\cdot|Y)$ arising from the formalism (7) is a (through Y) *random* probability measure in function space. Henceforth we assume that the data Y are generated from a fixed unknown probability distribution $P_{f_0} \equiv P_{u_{f_0}}$, where f_0 represents an arbitrary, hypothetically 'true', value. The first question we can ask is about 'consistency' of the posterior random measure in the sense that we want it to concentrate most of its mass near f_0, at least in the 'large sample' or 'small noise' limit where $n \to \infty$ or $\varepsilon \to 0$, respectively. Formally we want to find an as fast as possible rate δ_n (or δ_ε) such that in some metric d on function space,

$$\Pi(f : d(f, f_0) \geq \delta_n | Y) \to 0 \tag{9}$$

as $n \to \infty$ and in $P_{u_{f_0}}$-probability. Tools for this have been developed in remarkable depth and breadth in Bayesian Nonparametrics for direct problems, a key idea being 'robust testing in Hellinger distance'—see Ghosal and van der Vaart (2017) or Sections 7.1 and 7.3 in Giné and Nickl (2016). These methods however do not obviously adapt to the inverse problems setting, and new ideas are required. For linear inverse problems some tools exist, see Knapik et al. (2011); Agapiou et al. (2013); Ray (2013); Kekkonen et al. (2016); van Waaij and van Zanten (2016), covering in particular the problem involving the transport PDE (3) appearing with Radon transforms and the SDE problem (6) with $\sigma = 1$ and continuous data $(Y_t : 0 \leq t \leq T)$. Bute none of these proofs give a strategy to prove contraction rates for general, non-linear, inverse problems. In Ray (2013) an idea of Giné and Nickl (2011) is picked up to construct tests for linear problems replacing 'robust testing' by techniques from concentration of measure theory and nonparametric statistics. This allows to obtain contraction rates outside of the conjugate setting, an approach that generalises to the non-linear setting, as demonstrated in the recent papers Nickl and Söhl (2017); Nickl (2017) where the parabolic and elliptic problems from above were considered, respectively. In both it was found that the posterior contracts at optimal rates (in a minimax sense). For instance in the elliptic case (1) with $f_1 = 1$ known but unknown potential $f_0 \in C^s(\mathcal{O})$ a positive s-times continuously differentiable function on $\mathcal{O}$, if the observations are given in model (5), the contraction rates in $L^2(\mathcal{O})$-distance for a uniform wavelet prior are (up to log-factors)

$$\delta_\varepsilon \approx \varepsilon^{\frac{2s}{(2s+4+d)}} \text{ as noise level } \varepsilon \to 0.$$

In the parabolic case (2), when considering discrete (low frequency) data $Y_\Delta, \ldots, Y_{n\Delta}$ in the scalar diffusion model (6) with a suitable hierarchical prior construction, then if $f_1 \in C^{s-1}, f_2 \in C^s$, one obtains in (9) the rates

$$\delta_n = n^{-(s-1)/(2s+3)} \text{ for the drift coefficient } f_1$$

$$\delta_n = n^{-s/(2s+3)} \text{ for the diffusion coefficient } f_2,$$

as sample size n increases, again up to log-factors, and in L^2-distance. The proof techniques employed in Nickl and Söhl (2017) and Nickl (2017) depend on a few standard properties of the elliptic and parabolic problems that feature also in general inverse problems: Main analytic ingredients are a *stability estimate* for the forward problem that allows to control $\|f-g\|$ in terms of $\|u_f - u_g\|'$, in suitable norms $\|\cdot\|, \|\cdot\|'$, and a dual form of the usual *regularity estimates* for solutions of PDEs such as $\|u_f - u_g\|_{L^2} \lesssim \|f-g\|_{H^{-\alpha}}$ where $H^{-\alpha}$ is a negative Sobolev space with exponent α corresponding to the ill-posedness of the problem. If such estimates are available then tools from nonparametric statistics can be applied to deduce contraction rates for priors that generally do not require identification of a SVD-type basis underlying the forward operator.

§5. Microscopic Fluctuations of Solutions of Inverse Problems and the Fisher Information Operator

Once it is known that the posterior concentrates near the true value f_0 in a certain distance, it is natural to consider the fluctuations of $f|Y$ near f_0 when scaled by some inverse 'contraction rate'. The previous results were obtained for the distance function d induced by the L^2-norm, and one may thus initially consider the statistical fluctuations of the random variable

$$Z_\varepsilon = \delta_\varepsilon^{-1}(\bar{f}|Y - f_0) \text{ in } L^2.$$

Here some subtle geometric obstructions occur, some of which were already noted in the simplest infinite sequence space model in Freedman (1999)'s Wald lecture. Perhaps the easiest way to understand the issue is to anticipate the results that will follow: after centring Z_ε at its expectation, the marginal distributions of the process $(\varepsilon^{-1}\langle Z_\varepsilon - EZ_\varepsilon, \psi\rangle_{L^2} : \psi \in C^\infty)$ along smooth projection directions ψ will be seen to converge weakly in probability to a fixed non-degenerate Gaussian process $(\mathbb{G}(\psi) : \psi \in C^\infty)$. Note that here we have re-scaled by the larger ε^{-1} instead of δ_ε^{-1}. Since all sub-sequential distributional limits of random variables in function space are determined by the limits of such marginal distributions, a functional limit theorem in L^2 would also have to hold at rate $\delta_\varepsilon = \varepsilon$. But this would imply a contraction theorem as in (9) at that rate, which is impossible in light of lower bounds provided by statistical minimax theory for such estimation problems in Gaussian white noise (Chapter 6 in Giné and Nickl (2016)).

The way to overcome, or rather side-step, these obstructions, was set out in the papers Castillo and Nickl (2013, 2014). The idea is to determine *maximal* families Ψ of functions ψ for which the Gaussian asymptotics

$$(\varepsilon^{-1}\langle Z_\varepsilon - EZ_\varepsilon, \psi\rangle_{L^2} : \psi \in \Psi) \to (\mathbb{G}(\psi) : \psi \in \Psi) \quad (10)$$

can be obtained—by analogy to the classical result from parametric statistics these are often called 'nonparametric Bernstein–von Mises theorems'. Due to the maximality requirement such results are somehow 'dual' to obtaining contraction rates in L^2 (by using arguments from interpolation theory), but they allow to go beyond a mere convergence rate analysis: the Gaussian process $\mathbb{G}$ identifies the precise microscopic fluctuations of the posterior near f_0. While the results in Castillo and Nickl (2013, 2014) are confined to 'direct' problems in nonparametric regression and probability density estimation, in the recent articles Nickl (2017); Monard et al. (2017) the first such nonparametric Bernstein–von Mises theorems have been proved for PDE type inverse problems in the white noise model (5) (see also Nickl and Söhl (2017) for a non-linear inverse problem with jump processes).

To understand the nature of the microscopic fluctuations, let us first consider the transport PDE problem where the observations consist of the X-ray transform $u_{a,f} \equiv I_a(f)$ of the unknown source function f. When $\mathcal{O}$ is the unit disk the forward operator equals the standard Radon transform, but even in the general setting the linear operator I_a, known as the attenuated X-ray transform, is well studied in integral geometry. In Monard et al. (2017), using techniques from micro-local analysis, it is proved that the 'information' operator $I_a^* I_a$, where I_a^* is a natural adjoint operator, has an inverse $(I_a^* I_a)^{-1}$ that maps $C^\infty(\mathcal{O})$ isomorphically into $\{g/\sqrt{d_\mathcal{O}} : g \in C^\infty(\mathcal{O})\}$, where $d_\mathcal{O} = d(\cdot, \partial\mathcal{O})$ is the distance function to the boundary $\partial\mathcal{O}$ of $\mathcal{O}$. For natural Gaussian priors for f and posterior draws $f|Y \sim \Pi(\cdot|Y)$, it is then proved that, whenever $\psi \in C^\infty(\mathcal{O})$, as $\varepsilon \to 0$,

$$\varepsilon^{-1}\langle f|Y - E^\Pi[f|Y], \psi\rangle_{L^2} \to^d N(0, \|I_a(I_a^* I_a)^{-1}\psi\|^2) \quad (11)$$

in P_{f_0}-probability, where the norm on the right hand side is a natural L^2-norm on 'geodesic space'. The limiting covariance can be shown to be minimal in the sense that it attains the semi-parametric Cramér-Rao lower bound (or 'inverse Fisher information') for estimating $\langle f, \psi\rangle_{L^2}$ near f_0. The Gaussian nature of the posterior distribution combined with the Paley–Zygmund inequality then also shows that the Tikhonov regulariser $\hat{f}$ minimising (8) in this problem with any Sobolev-norm penalty satisfies, for any $\psi \in C^\infty(\mathcal{O})$ and as $\varepsilon \to 0$,

$$\varepsilon^{-1}\langle \hat{f} - f_0, \psi\rangle_{L^2} \to^d N(0, \|I_a(I_a^* I_a)^{-1}\psi\|^2),$$

a result that is of interest also outside of the Bayesian context (although its proof is 'Bayesian').

The findings in the transport PDE case foreshadow the general principle: the microscopic fluctuations of optimal inverse problem solvers will depend on the inverse Fisher information operator $(I_a^* I_a)^{-1}$, and its existence combined with mapping properties play a crucial role in proving Bernstein–von Mises theorems. For non-linear inverse problems, the information operator that has to be inverted is found after linearisation. This is demonstrated in Nickl (2017) for a prototypical elliptic PDE case (1) with $f_1 = 1$ and unknown potential $f = f_0$: basic perturbation arguments for the Schrödinger equation imply that in this case the role of I_a is replaced by $V_f[\cdot/u_f]$, where V_f is the inverse of the Schrödinger operator $S_f(u) = \Delta u - fu$, derived via PDE techniques or using semigroup theory for killed Brownian motion (see Chung and Zhao (1995)). In this case by self-adjointness of V_f the Cramer-Rao lower bound simplifies and the Bernstein–von Mises theorem becomes

$$\varepsilon^{-1}\langle f|Y - E^{\Pi}[f|Y], \psi\rangle_{L^2} \to^d N(0, \|S_{f_0}[\psi/u_{f_0}]\|_{L^2}^2) \quad (12)$$

in P_{f_0}-probability as $\varepsilon \to 0$, for every compactly supported $\psi \in C^\infty(\mathcal{O})$, and for $f|Y$ drawn from a posterior distribution corresponding to a natural uniform wavelet prior.

The limit theorems (11), (12) single out the Gaussian limit process $(\mathbb{G}(\psi) : \psi \in \Psi_a)$ towards which the centred posterior distribution will converge. We can then return to the program laid out in (10) and look for maximal classes Ψ of functionals ψ for which this convergence occurs simultaneously. As shown in Nickl (2017) maximal such classes can be characterised in terms of the sample continuity properties of the limiting Gaussian process, and in the elliptic PDE case equals a ball in the space $C_c^\alpha(\mathcal{O})$ of compactly supported α-Hölder functions with critical threshold $\alpha > 2 + d/2$. It is then further shown in the main theorem in Nickl (2017) that indeed the posterior distribution converges weakly to the law of $\mathbb{G}$ for the topology of uniform convergence on Ψ, in P_{f_0}-probability, giving the first optimality result of its kind for the Bayesian solution of a PDE-type non-linear inverse problem.

The Bernstein–von Mises theorems introduced here have important applications to the frequentist justification of Bayesian inference methods. Particularly they imply that Bayesian 'credible regions' and 'error bars' amount to proper confidence sets according to the usual 'frequency' interpretation of statistical significance. In particular, Bayesian inferences that have 95% posterior credibility will have approximately 0.95 chance of returning the correct decision in repeated trials. Once a Bernstein–von Mises theorem is at hand these facts are not specific to inverse problems and follow the general ideas developed in Castillo and Nickl (2013, 2014).

To conclude, the ideas presented here allow to derive precise microscopic fluctuations of inverse problem solvers from a careful study of the information operator underlying a given inverse problem. They provide a general template to prove similar results in various other settings. The main attraction of Bernstein–von Mises type results is perhaps that they reveal finer properties of an inverse problem than a mere convergence rate analysis does, via the covariance structure of the limiting Gaussian process. They also raise the interesting open question whether standard numerical inverse solvers attain the statistical information bounds that emerge from our theory, or whether they are potentially outperformed by Bayesian methods when interpreted as statistical algorithms.

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Obituary: In memoriam Alastair Scott

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Communicated by the Editor

Alastair Scott: 1939–2017.

Alastair Scott, one of the finest statisticians New Zealand has produced, died in Auckland, New Zealand on Thursday, May 25. He served the University of Auckland with distinction from 1972 to 2005.

His research was characterised by deep insight and he made pioneering contributions across a wide range of statistical fields. Alastair was acknowledged, in particular, as a world leader in survey sampling theory and the development of methods to efficiently obtain and analyse data from medical studies. His methods are applied in a wide range of areas, notably in public health. Beyond research, he contributed prolifically to the statistical profession in academia, government, and society.

Alastair was a Fellow of the Royal Society of New Zealand, the American Statistical Association, the Institute of Mathematical Statistics, the Royal Statistical Society, and an honorary life member of the New Zealand Statistical Association. In November last year, Alastair was awarded the Royal Society of New Zealand's Jones Medal, which recognised his lifetime contribution to the mathematical sciences.

Alastair gained his first degrees at the University of Auckland: BSc in Mathematics in 1961 and MSc in Mathematics in 1962. After a period at the New Zealand Department of Scientific and Industrial Research, he pursued a PhD in Statistics at the University of Chicago, graduating in 1965. He then worked at the London School of Economics from 1965–1972.

Alastair returned to New Zealand in 1972 to a post in what was then the Department of Mathematics and Statistics at the University of Auckland; he and wife Margaret had decided that they wanted to raise their children, Andrew and Julie, in New Zealand. Throughout his career, Alastair was regularly offered posts at prestigious universities overseas, but turned them down. However, he held visiting positions at Bell Labs, the universities of North Carolina, Wisconsin, and UC Berkeley in the US, and at the University of Southampton in the UK.

In 1994, the University's statistics staff, led by Professor George Seber, had a very amicable divorce from the Department of Mathematics and Statistics, and Alastair became the head of the new Department of Statistics. He helped set the tone for the department that still exists—hard-working, but welcoming, and social. The Department of Statistics is now the largest such school in Australasia.

In 2005, Alastair officially retired. A conference in Auckland that year in his honour attracted the largest concentration of first-rank international statisticians in New Zealand in one place at one time. Alastair kept an office in the department and continued writing and advising, coming into work almost every day.

Alastair Scott was an influential teacher and generous mentor to several generations of statisticians who valued his sage advice coupled with his trademark affability. Alastair had a full life professionally and personally. He was a wonderful teacher, mentor, colleague, and friend. We will all miss him greatly and we extend our sincere condolences to Margaret, Andrew and Julie, and his family, friends, and colleagues all over the world.

Past Conferences, Meetings and Workshops

Sponsored and Co-Sponsored by Bernoulli Society for Mathematical Statistics and Probability

The 39th Conference of the Bernoulli Society on Stochastic Processes and their Applications (SPA2017)

The 39th Conference of the Bernoulli Society on Stochastic Processes and their Applications (SPA2017) took place from 24 to 28 July 2017 in the Izmailovo Congress Center (Vega Hotel) in Moscow. After the First World Congress of the Bernoulli society, held in 1986 in Tashkent, Bernoulli society had no conferences on probability theory and random processes of such a size in the USSR and Russia. Steklov Mathematical Institute (Moscow) and the Institute for Information Transmission Problems (Kharkevich Institute) were the organizers of the conference. The Federal Agency for Scientific Organizations (FASO Russia), Russian Foundation for Basic Research (RFBR), Skolkovo Institute of Science and Technology (Skoltech), the Bernoulli Society, International Statistical Institute, Elsevier and Illinois Mathematical Journal also supported (in different forms) the efforts of the organizers to conduct the conference.

Stanislav Smirnov (Université de Genève) was the chair of Scientific Programme Committee, Vladimir Vatutin (Steklov Mathematical Institute) and Vladimir Spokoiny (WIAS, Berlin and Kharkevich Institute) were the co-chairmen of the Local Organizing Committee.

The program included 13 plenary talks, 71 invited talks, and 128 contributed talks by 283 participates from 39 countries around the world. In addition, several special sections were organized for the participants supported by Skoltech (6 talks), by Skoltech and Kharkevich Institute (4 talks) and by the Moscow Engineering Physical Institute (4 talks).

The following participants gave plenary lectures. Vladimir Bogachev (Lomonosov State Univerisity, Moscow) delivered the Doob lecture, on "Distributions of Polynomials in Gaussian Random Variables: Recent Progress and Open Problems"; Noemi Kurt (TU Berlin) the Itô prize lecture, titled "An Individual-based Model for the Lenski Experiment, and the Deceleration of the Relative Fitness"; Grigorii Olshanski (IITP) the Levy lecture, on "Point Processes Related to q-Hypergeometric Polynomials"; by Richard Kenyon (Brown University) the Schramm lecture, on "Limit Shapes Beyond Dimers"; IMS Medallion lectures were delivered by Takashi Kumagai (Kyoto University), on "Potential Theory for Symmetric Jump Processes and Applications"; by Marta Sanz-Sole (Universitat de Barcelona), titled *SPDEs : Probability laws and trajectories*; and further plenary talks were given by Zhan Shi (Universite Pierre et Marie Curie), titled "A Hierarchical Renormalisation Model"; by Cerrai Sandra (University of Maryland), "On the Small Noise Limit for Some Nonlinear SPDEs with Vanishing Noise Correlation"; by Lifshits Mikhail (St. Petersburg State University), titled "Energy Saving Approximation for Random Processes"; by Curien Nicolas (Universite Paris-Sud), on "Geometry of Random Planar

Maps and Stable Processes"; by Chelkak Dmitry (ENS Paris and PDMI RAS), titled "2D Ising Model at Criticality: Correlations, Interfaces and a Priori Estimates"; by Zhang Xicheng (Wuhan university), on "Ergodicity of Stochastic Differential Equations with Jumps and Singular Coefficients"; by Bordenave Charles (Institut de Mathematiques de Toulouse), titled "Non-backtracking Spectrum of Random Graphs."

The Bernoulli Society arranged a reception for new researchers (July 25) and Kavita Ramanan (USA) and Kostya Borovkov (Australia) described the goals of the Bernoulli Society, and what it offers to members. Participants of SPA2017 had also a chance to visit main attractions of Moscow: Kremlin and the Tretyakov gallery. Some participants had a possibility to enjoy a boat excursion along the Moscow river on part of July 26th.

The list of participants, the titles and abstracts of the talks presented at the conference as well as the slide versions of the plenary talks can be found at the Web page of the conference at

http://www.spa2017.org

Vladimir Vatutin
Moscow

Other Events

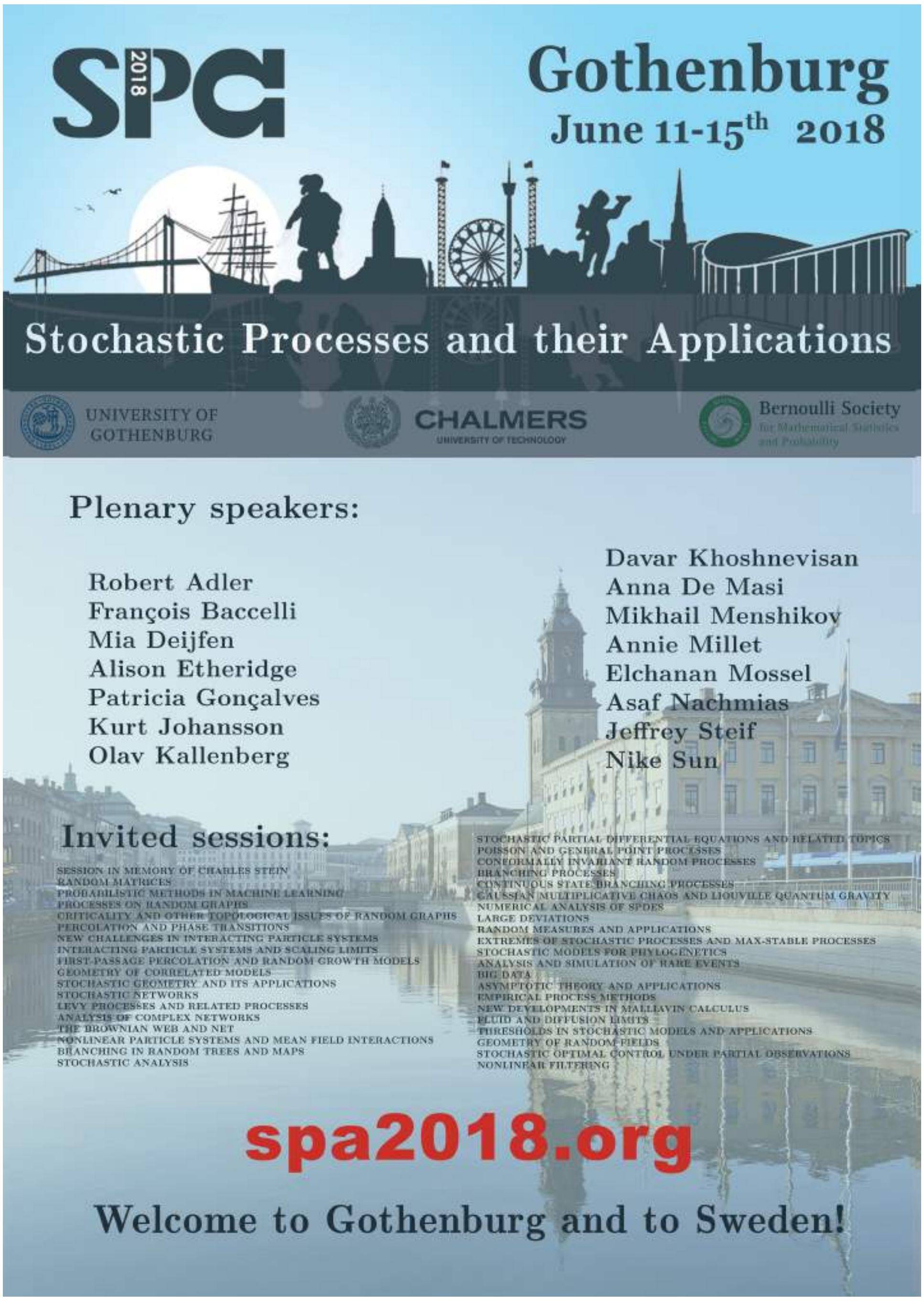
10th Conference on Extreme Value Analysis: June 26–30, 2017; Delft, Netherlands

The 10th Conference on Extreme Value Analysis was held on June 26–30, 2017 on the campus of the Delft University of Technology. The conference is the main scientific event on the subject and is organized every two years. Previous conferences were in Ann Arbor (2015) and Shanghai (2013); the next one will be in Zagreb (2019)! The Delft EVA conference attracted over 220 participants from more than 150 institutions all over the world and featured 36 invited talks and 122 contributed talks. The high quality invited sessions were organized by the members of the Scientific Committee: Anthony Davison, Clément Dombry, Holger Drees, Anne-Laure Fougères, Pieter van Gelder, Deyuan Li, Thomas Mikosch, Sidney Resnick, Stilian Stoev, Qihe Tang, Jonathan Tawn, and Chen Zhou. The 158 talks spanned a broad range of topics on extreme values, including univariate, multivariate and infinite-dimensional theory and various applications in fields like safety and security, (social) networks, weather and climate, insurance and finance, maximal human life span, earthquakes, and medicine. With 3-4 sessions simultaneously, participants could always find an interesting presentation. Furthermore the conference hosted a competition for the best paper of a young researcher (organized by the journal Extremes), a data challenge (organized by Olivier Wintenberger) and two discussion sessions, one on theory and one on applications. 20 Young researchers competed for the Extremes young researcher best paper prize and 9 of them were selected to present their papers in special sessions. At the beginning of the conference dinner, it was announced by the Editor of *Extremes* Thomas Mikosch that the jury awarded the prize to Johannes Heiny, Aarhus University, for his work on extreme eigenvalues of the sample correlation matrix, see picture. During the challenge session on prediction of extreme rainfall at different sites in The Netherlands, the final ranking was announced and 4 competitors presented their methods. The team from Melbourne University, consisting of Kate Saunders, Alec Stephenson and Laleh Tafakori, won the challenge by improving the prediction score of the 99.5% empirical quantiles by approximately 60%. On Monday evening, the busy welcome reception was held in the beautiful historical city hall of Delft. On Wednesday afternoon 120 people participated in the memorable and much appreciated excursion to the largest storm barrier in the world and the city of Middelburg. Clearly flooding problems are a main application of Extreme Value Analysis. On Thursday evening the excellent and very pleasant conference dinner was enjoyed by 160 participants. We received many positive reactions on both the scientific and the social program of the conference.

Juan-Juan Cai, Delft
John Einmahl, Tilburg

Forthcoming Conferences, Meetings and Workshops, and Calendar of Events

Sponsored and Co-Sponsored by Bernoulli Society for Mathematical Statistics and Probability



Other Events

ISBA World Meeting 2018: June 24–29, 2018; Edinburgh, UK

The world meeting of the International Society for Bayesian Analysis (ISBA) will take place in Edinburgh, a beautiful and historical location intimately associated with Thomas Bayes, who studied logic and theology at the University of Edinburgh as an undergraduate (circa 1719–1722).

ISBA 2018 is the continuation of the traditional Valencia/ISBA Meetings regularly held since 1979. They represent a unique event where the Bayesian community gathers together to discuss recent advances and the future of the profession.

The meeting will include Foundational Lectures presented by Alan Gelfand (Duke University), Anthony O'Hagan (University of Sheffield), Judith Rousseau (Dauphine University), and Ed George (University of Pennsylvannia). In addition, keynote speakers include Nicolas Chopin (ENSAE), Montse Fuentes (Dean, VCU), Steve MacEachern (Ohio State University), and Michael Jordan (UC Berkeley).

In the tradition of past events, workshops will be held on the weekend prior to the conference commencement. There will also be satellite meetings held at nearby locations both before and after the main conference. Details will be provided on the conference website in the coming months.

More information on the meeting is available from

`https://bayesian.org/isba2018`

We look forward to seeing you in Edinburgh.

Miguel de Carvalho
Edinburgh

Clair Alston-Knox
Nathan

ECMTB 2018: July 23–27, 2018; Lisbon, Portugal

ECMTB2018
LISBON

The 11th European Conference on Mathematical and Theoretical Biology (ECMTB 2018) will be held in Lisbon, Portugal, from 23 to 27 July, 2018. The venue is the Faculty of Sciences, University of Lisbon, and its research centre CMAF-CIO will host the event. This will be a main event of the Year of Mathematical Biology:

http://euro-math-soc.eu/year-mathematical-biology-2018

set up by European Society for Mathematical and Theoretical Biology (ESMTB) and the European Mathematical Society (EMS). For that reason, ECMTB 2018 will, for the first time, be a joint ESMTB-EMS conference and will be co-organized by SPM (Portuguese Mathematical Society). Bernouli Society (BS) cooperates in the BS–EMS Joint Lecture by Samuel Kou.

We invite all researchers and students interested in Mathematical and Theoretical Biology and its applications to join us on this exciting conference! Registrations are now open on the Conference webpage http://www.ecmtb2018.org. Applications to Minisymposia, Contributed Talks and Posters are also opened and the corresponding abstract templates are available on the webpage.

Important information and dates:

- Deadline: November 15, 2017.
- Acceptance Notification: January 15, 2018.

Abstract submission for contributed talks and posters are now open:

- Deadline: February 20, 2018.
- Acceptance Notification: April 2, 2018.

Early-bird fees: Please register before April 15, 2018. To stay updated on the latest news on the ECMTB 2018, follow us at

https://www.facebook.com/ecmtb2018

Looking forward to seeing you in Lisbon.

Maíra Aguiar
Lisbon
Carlos Braumman
Évora
Nico Stollenwerk
Lisbon

Calendar of Events

This calendar lists all meetings that have been announced in this and previous issues of *Bernoulli News* together with forthcoming meetings organized under the auspices of the Bernoulli Society or one of its Regional Committees (marked by ◎).

A more comprehensive calendar of events is available on the ISI Websites

- www.bernoulli-society.org/index.php/meetings
- www.isi-web.org/index.php/activities/calend

November 2017

- ◎November 29–December 1 (2017), *Statistics Meets Friends*; Göttingen, Germany.

February 2018

- February 27–March 2 (2018), *13th German Probability and Statistics Days*; Freiburg, Germany.

March 2018

- ◎March 29–31 (2018), *Frontier Probability Days 2018*; Corvallis, Oregon, US.

June 2018

- ◎June 11–15 (2018), *40th Conference on Stochastic Processes and their Applications*; Gothenburg, Sweden.
- June 24–29 (2018), *ISBA 2018 World Meeting*; Edinburgh, UK.

2019

- ◎*32nd European Meeting of Statisticians*, Palermo, Italy.

August 2020

◎August 17–21 (2020), *World Congress in Probability and Statistics*; Seoul, South Korea.

Quote of the Issue:

> *“Most importantly how do we utilize this complex data to benefit society? [...] The Bernoulli Society has a role to play in this changing world.”*

Susan A. Murphy

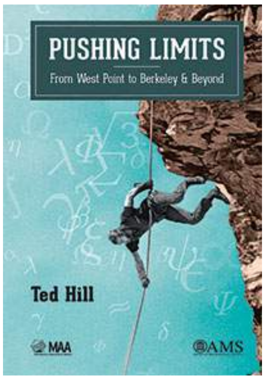
Book Reviews

Pushing Limits: From West Point to Berkeley & Beyond

By Ted Hill. A co-publication of the AMS and Mathematical Association of America

"**Pushing limits: The Indiana Jones of Mathematics**". In the faraway year of 1985 I was a young physicist with a summer job at CERN when advance copies of Richard Feynman's autobiography Surely you're joking, Mr. Feynman! were received in the library. I immediately grabbed and, since it could not to be borrowed, spent the whole night in the library and read it in one sitting. The at times exhilarating, at times hilarious, but always inspiring genius of Feynman pored through his adventures of a curious character.

Thirty years later, Ted Hill's Pushing limits: from West Point to Berkeley and beyond conveys the exact same sense of exaltation. Ted is a world-class mathematician—and, like Feynman's, his tales are almost unbelievable. If you open this book expect some kind academic or scientific autobiography, you are in for big surprises: the whole book reads like an Indiana Jones movie, packed with hard-to-believe adventures of an academic set loose in the world.



Ted has lived an incredibly rich life. The first chapter finds him as a cadet in West Point, and we quickly understand why. In a strict military school, his rebellious and resourceful nature start to show and he is already pushing the limits as they are imposed on him (and duly pays for it!). After a period at Stanford, Hill serves in the Vietnam war. His adventures there range from the dramatic to the hilarious (he even stole an Army jeep!). Upon being discharged from the Army he went on to Berkeley graduate school and tackled one of the toughest maths programs in the world at the heyday of Dubins and Smale—without a degree in Mathematics. Talk about self-confidence!

After his Ph.D. (which for a short time was a Ph. C., putting his career in jeopardy– you have to read the book), Hill landed a tenure-track job at Georgia Tech, where he managed a dream situation for a research mathematician: a job with one year leave of absence every two years (the leave was unpaid, but Ted Hill was "always frugal" and lived very happily with that).

And so Ted Hill managed to spend most of his life honing his parallel passions: doing mathematics and globetrotting the world. His many adventures are recounted like fireside tales: his naïve quest for gold in the Peruvian Andes, a two-month travel in a hippie VW camper deep into Soviet Russia at the height of the Cold War, camping out in Idi Amin Dada's Uganda or in no-man's-land between Tanzania and Zambia, swimming with sharks in the Bahamas, stealing a canoe at Berkeley, upside-down rappelling or getting caught on foot inside a tunnel when a train approaches at full speed. Twice. Move over, Indiana Jones! The mathematical side takes second stage; but all mathematicians can relate to the Eureka! moments appearing after chapter 10, or the several instances of the appearance of Benford's law, which in the late 1990s came to public attention as the basis of a IRS fraud- detecting scheme.

The final part the book proceeds into an unexpected pathos as it delves into a dark side of academia. Ted Hill discovered administrative wrongdoing at the highest level at Georgia Tech. His long and unnerving years-long fight after whistleblowing ended, sadly, with his own demise from Georgia Tech.

Then again, this was Ted Hill at his best: the courage to push the limits and to affront the powers that be, be they the laws of physics or the laws of men, coupled with an impeccable and unwavering sense of ethics. When asked "How do you keep from getting stuck in one groove and following a dull trail?" he answers: "I let my curiosity lead the way, just like on a new hike or dive." The question was about maths, but in fact it sums up Ted's attitude towards life.

Pushing limits.

Jorge Buescu
Lisbon

Recent Issues of Official Publications

Sponsored by Bernoulli Society for Mathematical Statistics and Probability

Bernoulli Vol. 24, No. 2: May 2018

Editor-in-Chief: H. Dette

http://projecteuclid.org/current/euclid.bj

Stochastic Processes and their Applications Vol. 127, No. 11: November 2017

Editor-in-Chief: H. Dehling

http://www.sciencedirect.com/science/journal/03044149

Bernoulli Society Bulletin e-Briefs Vol. 30: July 2017

Editor-in-Chief: C. Constantinescu

http://goo.gl/G9AOgl

Co-Sponsored by Bernoulli Society for Mathematical Statistics and Probability

Have a look at http://goo.gl/7EP2cZ for the latest articles in *Electronic Communications in Probability*, *Electronic Journal of Probability*, *Electronic Journal of Statistics*, *Probability Surveys and Statistics Surveys*, as well as *International Statistical Review*.

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"If you are alredy a member, encourage your colleagues, postdocs and PhD Students to join the Bernoulli Society."

Publications and Meetings

The Bernoulli Society official journals are *Bernoulli* and *Stochastic Processes and their Applications*. In addition, the BS co-sponsors the following open-access online publications: *Electronic Communications in Probability*, *Electronic Journal of Probability*, *Electronic Journal of Statistics*, *Latin American Journal of Probability and Mathematical Statistics*, *Probability Surveys* and *Statistics Surveys*. Published twice a year, *Bernoulli News* provides detailed information about activities of the Society, while *Bernoulli* e-*Briefs* is a bimonthly electronic information bulletin that summarizes and draws the attention of relevant information to the membership.

The Bernoulli Society organizes or sponsors several international meetings which have a prominent relevance in the fields of mathematical statistics, probability, stochastic processes and their applications.These meetings are often held in conjunction with the ISI andother ISI Associations, the IMS or by the BS Regional and Standing Committees. Some of the meetings with a proud tradition are the *Bernoulli-IMS World Congress in Probability and Statistics* every four years, the *Conference on Stochastic Processes and their Applications* (SPA) organized every year, the *ISI World Statistics Congress* (formerly ISI Session), the *Latin American Congress in Probability and Mathematical Statistics* (CLAPEM) organized every two or three years, the *European Meeting of Statisticians* (EMS) organized every two years and the *European Young Statisticians Meeting* (EYSM) organized every two years.

Benefits of Joining the Bernoulli Society

- Reduced registration fees for meetings organized or sponsored by the Bernoulli Society.
- Free online access to *Bernoulli* (back to the first issue in 1995) and to *Stochastic Processes and their Applications* (back to the first issue in 1973). Receive the print version of *Bernoulli News* and the electronic information bulletin *Bernoulli* E-*Briefs*.
- Reduced subscription rates are available for print copies of *Bernoulli* and *Stochastic Processes and their Applications*, and to online version of the ISI *International Statistical Review*.
- Printed version of the *International Statistical Review* (ISR) is also available at a reduced price.
- Special subscription rates on several journals in probability and statistics.
- Springer offers a 20% discount on their books, if ordered directly. Members with a BS-IMS joint membership have free on line access to the IMS journals: *Annals of Statistics*, *Annals of Probability*, *Annals of Applied Probability*, *Annals of Applied Statistics* and *Statistical Science*. They also have reduced subscription rates to print IMS publications.

Membership Application and Fees

Online Applications for Membership

- Bernoulli Society membership
  `http://isi.cbs.nl/bern-form.asp`
- Joint BS-IMS membership
  `https://secure.imstat.org/secure/orders/IndMember.asp`
- Joint BS-IMS-ISI membership
  `http://isi.cbs.nl/bern_ims_isi-form.asp`

Membership Fees for 2017

- Full members: €80,00.
- First year of membership for members from developed countries: €40,00.
- Members from developing countries, first two years of postdoc, retired members: €24,00.
- Joint BS-IMS memberhip: $165.00.
- Joint BS-IMS-ISImembership(only for elected ISI Members):€168,00
- PhD Students: Free!!!