Bernoulli News

Newsletter of the Bernoulli Society For Mathematical Statistics and Probability

Vol. 27 (1), May 2020 Published twice per year by the Bernoulli Society ISSN 1360–6727

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† *Bernoulli News is the official newsletter of the Bernoulli Society, publishing news, calendars of events, and opinion pieces of interest to Bernoulli Society members, as well as to the Mathematical Statistics and Probability community at large. The views and opinions expressed in editorials and opinion pieces do not necessarily reflect the official views of the Bernoulli Society, unless explicitly stated, and their publication in Bernoulli News in no way implies their endorsement by the Bernoulli Society. Consequently, the Bernoulli Society does not bear any responsibility for the views expressed in such pieces.*

A VIEW FROM THE PRESIDENT

Dear Members of the Bernoulli Society,

These are times of hardship and worry for all of us, and I hope that we can survive this pandemic without great damage. As more or less expected, we had to postpone our World Congress in Seoul this August, due to travel restrictions worldwide, but also out of responsibility for our speakers and participants, and for all local staff. Our sympathy is with all of them, and in particular with the local organizing committee, led by Hee-Seok Oh, and all other colleagues who have worked so hard for many years for this important Congress to happen. **The Bernoulli-IMS World Congress has been postponed to July 19-23, 2021.** The Young Researcher Meeting is also postponed to July 17-18, 2021. We hope to see many of you in Seoul in 2021 and ask you to

Note this conference in your diary!

Most of us will be grateful to all those colleagues who have initiated virtual seminars and workshops. The Bernoulli Society is very happy to spread the word, and you will find already some examples on our homepage. In these times it is important to keep our community in close contact, by offering and supporting initiatives also to young researchers. Please don't hesitate to send information about such activities to Leonardo (leonardo.rolla@gmail.com) or myself (Bernoulli.President@ma.tum.de).

Get involved in virtual activities!

We have reactivated our East Asia and Pacific Committee, chaired by Bikramjit Das from Singapore, and new Committee members have been elected. They plan various activities already, and also ask for support and ideas from BS members in this area. Please share new ideas and future activities in this region with Bikram (bikram@sutd.edu.sg) or myself.

Support the activities of the new EAPRC!

As already reported in the previous BNews, former BS President (2013-2015) Wilfrid Kendall celebrated his 65th birthday last December. Moreover, our long-standing BS member Peter Donnelly has been knighted for his services to the understanding of human genetics in disease by Queen Elisabeth last summer. This Newsletter contains two exciting interviews with both our colleagues.

Bernoulli Society is proud of their celebrated members!

We all want to keep ourselves informed about the coronavirus and you may have your own sources of information, but also ISI has summarized some useful links at `https://www.isi-web.org/index.php/covid-19`. An urgent call for scientists to support epidemic modelling was coordinated by the Royal Society at `https://royalsociety.org/news/2020/03/Urgent-call-epidemic-modelling`. Again I learn from this (of course, in principle we all know it), how important epidemic models, their analysis, simulation, and statistical fitting is. In other words, how important our profession is, so in spite of all our worries, a reason for being proud to belong. See also the quote of the issue on p. 20.

Stay active and contribute!

Hopefully we all stay healthy and in good spirits!

Claudia Klüppelberg
President of the Bernoulli Society
Munich

Deadline for the next issue: **30 September, 2020**
Send contributions to: *manuele.leonelli@ie.edu*

Editorial

I hope this new issue of Bernoulli News can bring a little bit of distraction during these uncertain times. We have collected some great material for this issue, notably two extremely interesting interviews with Peter Donnelly (a long-term member of the society) and Wilfried Kendall (a past president!). You can find these on pages 7 and 10, respectively. For an early-career researcher as myself, it is fascinating to read about their careers and lives as renowned statisticians. The issue also includes a very interesting article on random planar maps by Nina Holden (one of the winners of the Bernoulli Society New Researcher Award 2020) that you can find on page 14.

Please join me in congratulating Byeong Uk Park, our own past Scientific Secretary, for receiving the 33rd Inchon Award one of the major awards in the Republic of Korea. You can read more about it on page 3. This issue also include the profiles of the winners and the short-listed candidates of the Bernoulli Society New Researcher Award 2020 on page 4. A big congratulations to all these tremendous researchers!

You will notice that this issue does not have a future meetings section, due to the uncertainty generated by the Covid-19 emergency. Conversely, there is a calendar of future events only, but be aware that scheduled events may still be affected and postponed. Because of this, I join our president in encouraging you to join online seminars (for instance those listed on the Bernoulli Society homepage at http://www.bernoulli-society.org/index.php) or to watch some of the amazing recorded lectures available in the video section of the Bernoulli Society website (at http://www.bernoulli-society.org/index.php/videos).

The Editor
Madrid

Snapshots

C(PS)2: Uncertainty Quantification for the Future

The C(PS)2 committee is working across disciplines to facilitate the initialization of developments towards solving one of our greatest challenges – to ensure infrastructure resilience. This topic gained its momentum after Hurricane Katrina in 2005, where it became clear how vulnerable our developed world actually is. It was realized that preparedness, strategies and measures for recovery and adaptation after even unexpected impact is key to our societal capacity to cope with disasters and catastrophes. There is an urgent need for cost effective and efficient solutions to remedy the lack of resilience of our infrastructure. However, in the broader context of climate change, it became clear that our assumptions of stationarity are not valid, so that our predictive technologies fail to deliver reliable results. Phenomena such as cascading failures in complex interconnected systems have become much more prominent. That is, fundamental novel developments are needed to address the problems. Driven by this understanding, infrastructure resilience has emerged as a central topic of the United Nations Office for Disaster Risk Reduction, and it has been translated into one of the 17 "Goals to Transform Our World" of the United Nations Sustainable Development Agenda 2030. The National Academy of Engineering has defined "Restoring and Improving Urban Infrastructure" as one of the 14 "Grand Challenges for Engineering in the 21st Century". While first developments to address this challenge focussed on phenomenological approaches, treating the symptoms and looking at partial problems only, the clear understanding has grown that the problem can only be solved by developing a comprehensive, coherent approach to infrastructure resilience, attacking and resolving the root causes of the deficiencies. Such development, however, requires deep interdisciplinary collaboration and is still in an infancy stage.

Technically, it involves the challenge of representing our real world infrastructure by realistic and powerful numerical models including all uncertainties. While our real-world systems and their environment grow rapidly in scale, complexity and interconnection, uncertainties and risks become involved to a greater extent than ever before. Clearly, statistical and probabilistic methods provide the key access for solution. However, the magnitude and the complexity of the challenge exceed the capabilities of traditional approaches. Thus, novel pathways for extracting, quantifying, processing and evaluating information dealing with the entire range from sparse to big data are essential for making progress. The Bernoulli Society, and specifically the C(PS)2, are uniting the required skills in their community, thus being called by our society to set the fundamental basis for progress.

The C(PS)2 committee is pushing towards taking up this call and opportunity with a number of targeted initiatives. Our goal is to encourage collaboration between the research communities and to utilize synergies as seeds for out-of-the-box, high-impact approaches. As such, we connect the very community of probability and statistics to the communities of complex network data modeling and applications of probability and statistics in engineering sciences.

We extrapolated from the momentum set in this direction in the previous years and organized four cross-disciplinary sessions and mini-symposia at international key conferences within the past year. In order to magnify the impact of our activities by embracing a larger community with our vision we moved forward to organizing entire conferences. In 2019 we organized two major interdisciplinary conferences.

The 9th International Conference on Quality, Reliability, Risk, Maintenance, and Safety Engineering (QR2MSE 2019) was co-organized in Zhangjiajie, Hunan, China, August 06-09, 2019. Chaired by Profs. Hong-Zhong Huang, Michael Beer & Jae-Hak Lim, this conference expanded our collaboration with the communities in Asia, and in particular in China. Technically, it was devoted to reinforcing probabilistic and statistical developments on asset management, reliability and quality tools in design, manufacturing, and operation and maintenance of engineering systems. The conference attracted 476 participants from 21 countries with 307 papers published in the conference proceedings.

The 29th European Safety and Reliability Conference (ESREL 2019) was organized in Hannover, Germany, 22 - 26 September 2019. Chaired by Profs. Michael Beer and Enrico Zio, ESREL has established a close connection to the European Safety and Reliability Association. It formed a multi-disciplinary forum for the exchange of knowledge and expertise on theories and methods in the field of risk, safety and reliability, and on their application to a wide range of industrial, civil and social sectors and problem areas. This conference attracted 664 participants from 49 countries with 624 papers accepted. Again, the conference served as a connector to Asia, and in particular to China with 105 participants. In addition, we used ESREL to promote our activities in a broader way. First, we achieved a significant participation (at 28%) by PhD students, who can carry our vision forward to the next generation for materializing the developments in research and practice. Second, we attracted broader attention and reinforced connections to communities through distinguished plenary speakers. Among them were Prof. KK Phoon, Vice Provost of National University of Singapore, Humboldt Research Award Winner and Academic Adviser to the Global Risks Report 2017 of the World Economic Forum, Prof. Jie Li from Tongji University, President of the International Association for Structural Safety and Reliability and Director of the International Joint Research Center for Engineering Reliability and Stochastic Mechanics, and Dr. Luis G. Crespo from NASA Langley Research Center, USA. Third, we promoted the importance of our developments to stakeholders and the public; the conference was opened by Minister Björn Thümler, Minister for Science and Culture of the State of Lower Saxony, and the opening was featured on TV with an interview of Minister Thümler on the importance of developments in the area of the conference. At local level, we organized an associated public event as an open forum for discussion on current challenges that connected researchers and the urban population.

These conferences served as catalysts for the communities to better understand the importance of interdisciplinary collaboration and to promote our developments and visions to stakeholders and to the public. These activities are built upon the strong sustained engagement by all C(PS)2 committee members, the efforts of which are highly appreciated at this point.

Michael Beer and Konstantin Zuev
Current and past Chair of C(PS)2
Hannover, Pasadena

Activities Performed by the LARC-SLAPEM Committee

The Latin American Regional Committee (LARC) of Bernoulli Society was created in the 80's to promote regional cooperation in the fields of probability and mathematical statistics and their applications. In 2007 the Latin American Chapter of the Bernoulli Society changed its name and structure to Sociedad Latinoamericana de Probabilidad y Estadística Matemática (SLAPEM) and its committee continued being the LARC of the Bernoulli Society.

The main regular activities of LARC are the promotion of CLAPEM, the Latin American Congress of Probability and Mathematical Statistics, and the organisation of the Francisco Aranda Ordaz Prize before each edition of CLAPEM. The Francisco Aranda Ordaz Prize, created to honor the memory of a distinguished young Mexican statistician who died tragically in 1991, recognises the quality of a PhD thesis in Probability and of a PhD thesis in Mathematical Statistics, defended by a Latin American PhD candidate or in a Latin American Institution.

The last edition of CLAPEM took place in December 2019 in Mérida-Yucatán, Mexico. I invite the readers to access the webpage `http://clapem2019.eventos.cimat.mx/home` for an account of the conferences and contributed works presented during the event.

I would like to thank to everyone who contributed to the continuation of the activities promoted by SLAPEM, specially the members of LARC, the Organising and Scientific Committee of XV CLAPEM, and the members of the jury of the Francisco Aranda Ordaz Prize. Without the efforts of the community these activities would not be possible. Finally, I would like to congratulate the winners of Francisco Aranda-

Ordaz Prize, whose names and institutions can be accessed in http://www.bernoulli-society.org/index.php/organization/slapem/awards, for the excellent quality of their works.

Florencia Leonardi
Chair of LARC-SLAPEM Committee
São Paulo

Awards and Prizes

SLAPEM announced the winners of the 2019 Francisco Aranda Ordaz Prize

From 20 thesis in Statistics and 6 in Probability, all of them with a high scientific value, the Prize Committee, coordinated by Pablo Ferrari, established a shared Prize in Statistics and one winner for Probability thesis, with one honorable mention. The winners were announced during the XV Clapem in Mérida-Yucatán, México.

For statistics the winners are: **Leonardo Fabián Moreno Romero**, "*Estadística para datos en espacios no euclídeos: Algunas contribuciones*". Universidad de La República, Uruguay. Advisors: Ricardo Fraiman y Frabrice Gamboa; **María Antonella Gieco**, "*Dimensión efectiva en escenarios de alta dimensionalidad*". Universidad Nacional del Litoral, Argentina. Advisors: Liliana Forzani y Carlos Tolmasky.

For probability: **Avelio Sepúlveda**, "*Exit sets of the continuum Gaussian free field in two dimensions and related questions*". ETH Zürich, Switzerland. Advisor: Wendelin Werner. Honorable Mention to **Érika B. Roldán Roa**, "*Topological, geometric and combinatorial properties of random polyominoes*". Centro de Investigación en Matemáticas, México. Advisors: Víctor Pérez-Abreu y Matthew Kahle.

Florencia Leonardi
Chair of SLAPEM
São Paulo

Byeong Uk Park receives the 33rd Inchon Award

Byeong Uk Park, Professor of Statistics, Seoul National University, has received the 33rd Inchon Award, which is recognized as one of the major awards in Republic of Korea. Inchon is the pen name of a famous Korean who established "Korea University", "Dong-A Daily News" (a very popular newspaper in the nation) and held the office of Vice-President of Republic of Korea about 70 years ago. Four prizes are awarded each year, one to each of the four fields: Education; Journalism and Culture; Humanities and Social Sciences; Science and Technology. Professor Park won the award in the field of Science and Technology for the first time in statistical science. Each recipient of the award is presented with the Letter of Citation, a medal, and a cash prize of 100M Korean Won. Byeong U. Park is currently a Vice President of the ISI and an IMS Council member. He served as the Scientific Secretary of the Bernoulli Society and was elected to Fellows of the IMS and of the ASA.

Please join me in congratulating Byeong for this terrific achievement!

The Editor
Madrid

Bernoulli Society New Researcher Award 2020

The New Researcher Award is meant for Bernoulli Society members who are active researchers of mathematical statistics. The main goal of this award is to recognize innovative research by new researchers. Out of 29 applications, the award committee chose the following new researchers for the award: **Nina Holden** (ETH Zürich), **Li-Cheng Tsai** (Columbia University), **Xin Sun** (Columbia University). Each of the above awardees is going to deliver a 30-minute talk at the 10th Bernoulli-IMS World Congress in Probability and Statistics in Seoul, Korea. Given the strong pool of applicants for this award, the committee has chosen the following new researchers as honorable mentions: **Anirban Basak** (International Centre for Theoretical Sciences), **Ellen Powell** (ETH Zürich), **Nicholas A. Cook** (Stanford University), **Sarah Penington** (University of Bath). Pictures and short bios of the awardees are given below.

Nina Holden earned her B.Sc. and M.Sc. degrees in Mathematics and Computational Science from the University of Oslo in Norway. She then earned her Ph.D. in Mathematics at MIT and is currently a Junior Fellow at ETH-ITS in Zürich. In fall 2020 she plans to join the faculty of the mathematics department at the Courant Institute, NYU. Holden does research in multiple areas of probability theory. In a series of papers with various co-authors including Sun, she showed that when uniform random planar maps are embedded in the plane in a particular way, they converge in law to a so-called Liouville quantum gravity surface. In addition, she has done groundbreaking work on Schramm-Loewner evolutions, trace reconstruction, and various kinds of graph limits.

Li-Cheng Tsai received a B.Sc. in physics from the National Taiwan University and his Ph.D. in Mathematics from Stanford University. He joined Rutgers University in 2019 after being a Ritt assistant professor at Columbia and a junior fellow of the Simons Society of Fellows from 2016-2019. Tsai works at the interface of stochastic partial differential equations, large deviation theory and integrable probability – and has made major contributions in each area. For example, his recent paper ”Exact lower tail large deviations of the KPZ equation” elegantly resolved a conjecture of great interest from physics by combining random matrix methods with Brownian large deviations. An earlier major work was the derivation of the KPZ equation for certain non-local exclusion processes.

Xin Sun earned a B.Sc. degree in Mathematics from Peking University and a Ph.D. from MIT. Sun is currently a Junior Fellow at the Simons Society of Fellows, working in the Department of Mathematics at Columbia. Sun plans to join the faculty of the mathematics department at the University of Pennsylvania this fall. In a series of papers with various co-authors including Holden, he showed that when uniform random planar maps are embedded in the plane in a particular way, they converge in law to a so-called Liouville quantum gravity surface. Sun has established a wide variety of limit theorems for random planar maps decorated with statistical physics structures, and he has also done fundamental research on Gaussian free fields, fractional Gaussian fields, uniform spanning trees, random matrices, and the Airy line ensemble.

Anirban Basak got his B.Sc. and M.Sc. from the Indian Statistical Institute, Kolkata, and his Ph.D. from Stanford. He is now a Reader at the International Center for Theoretical Science, Bangalore, India. Basak's work spans several areas, with a diverse group of collaborators. In random matrix theory, he studied non-normal matrices, and in particular the spectrum of sums of random unitary matrices, and random permutations. He obtained sharp results on the invertability of random matrices and random regular graphs, in the sparse regime, as well as sharp large deviations bounds for the upper tail of sub-graph counts. He also studied the perturbations of (non normal) Toeplitz and twisted Toeplitz matrices under additive weak noise, and obtained a description of the limiting spectrum and outliers. He also studied statistical mechanics models (such as Ising and Potts) on asymptotically regular and tree-like graphs.

Nick Cook received his B.Sc. from the University of North Carolina and his Ph.D. from the UCLA, and is now a Stein Fellow at Stanford University. His research centers on random matrix theory and its connections to high-dimensional probability, random graph theory, free probability, and analytic number theory. A particular focus is on understanding the spectral statistics of non-Hermitian random matrix models with some weak coupling between matrix entries, such as the adjacency matrix for a random regular digraph, or the sum of random permutation matrices. In particular, Cook and coauthors established the celebrated ”circular law” for the asymptotic distribution of eigenvalues of such random matrix models. More recently, Cook has investigated large deviation inequalities for random matrix and random graph models, for instance computing the rate function for subgraph counts for sparse Erdős–Rényi graphs.

Sarah Penington completed her B.Sc. at the University of Cambridge and her Ph.D. at the University of Oxford in 2016. Then she was the G. H. Hardy Junior Research Fellow at New College, Oxford. She was awarded the 2018 Corcoran Memorial Prize for outstanding graduate work. Since September 2018, she has been a Prize Fellow at the University of Bath. Her work is mostly motivated by questions from population genetics, and often involves studying branching processes with spatial structure where nearby particles can interact. She has also used probabilistic techniques to prove new results about partial differential equations, with a particular emphasis on Fisher-KPP type reaction diffusion equations with non-local interactions.

Ellen Powell got her B.Sc., M.Sc. and Ph.D. from University of Cambridge. Shen then held a postdoc position at ETH Zürich and is now a lecturer (tenured assistant professor) at the University of Durham in the UK. She is also a former president of the Emmy Noether society for women in mathematics. Powell's work is in the area of random geometry, a branch of probability which deals with geometric properties of random processes, usually in connection with statistical physics and/or quantum field theory. Key examples are given by the Gaussian Free Field and the Schramm-Loewner Evolution. These two objects are related in many nontrivial ways including via the theory of Gaussian Multiplicative Chaos, to which she has made fundamental contributions, in particular in the so-called critical case. For instance, she was able to show convergence and uniqueness of the limit for critical GMC in its derivative normalisation.

Leonardo T. Rolla
Publicity Secretary
Buenos Aires

New Executive Members in the Bernoulli Society

Chair of East-Asian and Pacific Committee: Bikramjit Das

Short Bio: Bikramjit Das is an Associate Professor in Engineering Systems and Design at Singapore University of Technology and Design (SUTD). He obtained his PhD in Operations Research (2009) from Cornell University. He held a post-doctoral position at the RiskLab at ETH Zurich before joining SUTD in 2012. Bikram's research is in understanding rare events and heavy-tails with tools from probability, statistics and optimization. The application areas for his research spans risk management in finance and insurance, social network analysis, operations management and more. He currently serves as an associate editor for Stochastic Models.

Vision on EAP Regional Committee: It is an honor to take over the role of the chair of Bernoulli-EAPRC from Kostya Borovkov. The relevance of probability and statistics in so many facets of our personal and professional life is undeniable. The goal of the Bernoulli-EAPRC is to keep these areas relevant and active by organizing meetings and fostering collaborations in the East-Asia Pacific region. Keep an eye out for the Bernoulli-organized sessions at IMS-APRM 2021 in Melbourne.

Membership Secretary: Sebastian Engelke

Short Bio: Sebastian Engelke is assistant professor at the Research Center for Statistics at the University of Geneva, Switzerland. He obtained his PhD in Mathematics from the University of Göttingen in 2013. Sebastian was previously a research fellow at EPF Lausanne and a visiting professor at the University of Toronto from 2018-2019. His research interests are in extreme value theory, spatial statistics, graphical models and causal inference. He has received several grants and awards including a research fellowship at the Fields Institute in Toronto and an Eccellenza grant (2020-2025) that focuses on the connection of extremes to graph structures, sparsity and high-dimensional inference. Sebastian is an Elected Member of the ISI and currently serves as Associate Editor of the journals Extremes, the Scandinavian Journal of Statistics and Dependence Modeling.

Vision as Membership Secretary: It is my great pleasure to take over the role as Membership Secretary from Leonardo Rolla. I would like to use this opportunity to thank him for the excellent work he did serving our members, and I wish him all the best for his new role as Publicity Secretary. Research in probability, statistics and data science in the 21st century is continuously gaining importance. The members of the Bernoulli Society form a worldwide network with the goal to accompany and guide this development and to make the growing knowledge available to a broad public. In the coming years, we will continue to provide our members with the benefits that help them achieve these goals. I believe that it is of great importance to encourage our colleagues, and especially young researchers, to join our Society and to actively participate in the numerous meetings and working groups that we are sponsoring. To this end, I plan to collaborate closely with our Youth Representative, for instance on the New Researcher Awards. The Bernoulli Society is a community without boundaries and we will continue our efforts to stay also attractive and accessible to our colleagues from developing countries.

Chair of the Committee for Conferences on Stochastic Processes: Christina Goldschmidt

Short Bio: Christina Goldschmidt is a professor of Probability in the Department of Statistics at the University of Oxford, and tutorial fellow at Lady Margaret Hall. She obtained her PhD from the University of Cambridge in 2004, under the supervision of James Norris. After postdoctoral work at Paris VI (with Jean Bertoin), Cambridge and Oxford, she took up a faculty position at Warwick in 2009, before returning to Oxford in 2011. Her research mostly concerns random discrete structures. She has worked extensively on processes of coalescence and fragmentation. Much of her recent work has been on random trees and random graphs, and she has a particular interest in scaling limits of these objects. Christina was an IMS Medallion Lecturer at the 2016 IMS/Bernoulli World Congress in Toronto and was elected a fellow of the IMS in 2019. She has given various plenary lectures, including at the Seminar on Stochastic Processes at Stanford in 2009 and at SPA 2011 in Oaxaca. She is currently a member of IMS Council. She has in the past acted as an associate editor for Stochastic Processes and their Applications and Annals of Applied Probability, and is currently on the board of Electronic Journal of Probability and Electronic Communications in Probability.

Interviews

An Interview with Peter Donnelly

Wednesday 2 October 2019, at Genomics plc
Interviewer: Gesine Reinert

Peter Donnelly is Professor of Statistical Science at the University of Oxford, and the CEO of Genomics plc. He has produced seminal work in applied probability and the statistical methods he has developed for analysing genetic and genomic data have been widely used, with over 40,000 citations. Peter has been one of the international leaders of what has been called "The Genetic Revolution" – the explosion in our knowledge of the genetic basis of common human diseases. He was knighted in the British 2019 Birthday Honours for services to the understanding of human genetics in disease. His most recent award is the Genetics Society Medal 2020, an award that recognizes outstanding research contributions to genetics.

What thoughts went into when you went to graduate studies and where you would study?

I grew up in Australia and was also an undergraduate there. Towards the end of my undergraduate career, I was keen on gaining some research experience and obtained what is called a summer scholarship to the Australian National University. This gave me an early introduction to research which I really enjoyed. People who were advising me in Australia strongly recommended that I take the opportunity to go abroad to study for a doctorate, which I was keen to do anyway. It provided an opportunity to see the world beyond Australia.

So I pursued graduate possibilities in the US and the UK. I was very fortunate to obtain a Rhodes Scholarship. The Rhodes is a scholarship specifically to Oxford, and having accepted it, I was destined for Oxford.

Why did you choose applied probability for your research area?

During my undergraduate degree, which was largely mathematics, I had developed an interest for probability and statistics, in particular the probability part; so that was the area that I was most keen to explore further.

Did you benefit from any mentoring while you were a student?

Ted Hannan looked after me for the three months I was on the vacation scholarship at the Australian National University, and he was inspirational. While his main research area was time series, which was not my particular focus, he was very supportive, and encouraged me to look abroad for graduate studies.

Then, when I came to Oxford, I was supervised by John Kingman during my first year. (In the system at the time, doctorates involved no coursework and were entirely thesis-based.) While I was working in Oxford with him, Kingman carried out his fundamental work in genetics, around what has come to be called the "Kingman Coalescent", but it was not part of my doctoral research at that time. The irony was that soon after that, and for many years, it became a major focus for me. Kingman then left Oxford to head one of the Research Councils and Dominic Welsh then took over as supervisor for what was the major part of my doctoral work. John Kingman and Dominic Welsh are very different personalities, but both were helpful. Dominic was full of enthusiasm and very collaborative which worked really well for me.

Then you had a stellar career, at age 29 becoming possibly the youngest person to hold a chair at any university in the UK. How did you happen to move into genetics?

Indeed, I have been very lucky in many ways. A substantial portion of my early research concerned models in mathematical population genetics - stochastic models for the way in which the genetic composition of a population changes through time as the population evolves. I enjoyed this research area very much, but over time my own interests evolved.

Looking back, one thing I have learned about myself is that I love doing and learning new things. Early in my career I was doing applied probability work. I then got interested in some of the statistical questions arising when genetic data are available: how can we carry out statistical inference based on such models? Those are really interesting questions because although the probability models are relatively straightforward to simulate from, you cannot write down likelihoods, and hence inference is not direct. Those were the early days of MCMC – I learnt a lot about computational inference, and made some contributions in terms of computational approaches to statistical inference for coalescent models.

In the mid 1990's I moved to the University of Chicago, to a joint appointment between the Departments of Statistics, and of Ecology and Evolution. In Chicago I was actually sitting for part of my time in a real science and biology department, and through very helpful (and patient!) colleagues I started to learn some of the science. Over time, I evolved from being someone who is primarily interested in the mathematics and statistics, to get to the stage where I was really interested in the science questions in their own right. I became driven by wanting to understand the science and to learn fundamentally new things about biology and human disease. I became focussed on the science but with a rather different toolkit from most people in the field.

Was it an easy transition? Are there cultural differences?

As high-throughput experimental techniques changed the scale of genetic data available (an early example of what subsequently came to be called "big data"), the ability to do probability modelling and sophisticated computational statistics was a real advantage. The next piece of good fortune I had was in finding myself at the centre of the major international genomics project of the early 2000's, when I co-led the Analysis Group of the International HapMap Project, the study of global patterns of genetic variation which followed on from the Human Genome Project. This was a fantastic opportunity to work with some of the leaders in the field and to feel that one was making a contribution. After that, I was asked to lead what became known as the Wellcome Trust Case Control Consortium (WTCCC), the first very large-scale study of the genetic basis of human diseases. We studied 14 different diseases in a large sample size of 17,000 individuals, each measured at over 500,000 positions in their genome. The project became a landmark study, perhaps even a turning point, in the human genetics field. It was one of the pioneers among what have become many studies that have revolutionised our knowledge of the genetic basis of common human diseases. The WTCCC was a large UK-wide collaboration of 20 or 30 research groups and 200 scientists, and I felt hugely privileged to lead it with a steering committee of the preeminent UK human disease geneticists. (As others have found, there can be advantages in that kind of leadership role in having an analytical background, rather than a focus on a particular one of the diseases studied.) This project then led to me being asked to become Director of a large interdisciplinary research centre in Oxford (and I think one of the leading human genetics centres globally), called the Welcome Centre for Human Genetics, with over 40 research groups and about 400 scientists. I was Director of the centre for more than 10 years and loved it; it was a fantastic job. The Centre is very interdisciplinary and its research groups all try in different ways to use genetics as a route to understanding human diseases better, with the ultimate goal being to facilitate the development of new treatments for those diseases.

In parallel, I had a number of other research interests such as a longstanding interest in using genetics to understand population history. In one study, the "People of the British Isles", we used large-scale genetic data on 2,000 individuals and sophisticated statistical analyses to reveal a range of new insights into the peopling of the British Isles over the last 10,000 years, and to resolve a number of longstanding controversies in history and archaeology. A subsequent study of the Iberian Peninsula shed new light on population movements in what are now Spain and Portugal and migrations there over the last 1500 years.

I also have a longstanding interest in recombination and meiosis - the fundamental biological process that results in sperm or eggs being formed. All of our cells have two copies of our chromosomes, one from our mother and one from our father. When we pass our DNA onto our children, we pass it on in sperm (for males) or eggs (for females). Those cells have exactly one copy of each chromosome, so that, when sperm and egg unite, you end up with an individual whose cells have exactly two copies again. Meiosis, the biological process in which sperm and eggs are produced, where cells go from having two copies of their chromosomes to just one, turns out to be incredibly intricate. Although it is central to all of life, there are many aspects of meiosis which are just not understood scientifically. We often talk of "the mystery of life". Well, meiosis sits right at the centre of that mystery.

For almost 20 years now I have worked on better understanding some of the key processes within meiosis and for much of the last decade the central focus of my work has been experimental. I direct an experimental lab where my group (but not me!) undertake reasonably sophisticated experiments in model systems where we use genomic assays to try to unpick the roles of several of the key proteins at different stages of meiosis. It is a world of reasonably hardcore molecular biology, though in our case still aided by cutting edge computational analyses, which seems quite a long way from my early days in research in applied probability.

I have always loved collaborating and I have been really blessed with the calibre of people I've been able to work with – students, postdocs, and senior collaborators. I was lucky that I moved into genetics at a time when there was a massive change in the type of experiments that could be done and the type of data that could be generated to study the key questions. The explosion in high-throughput techniques which can generate large amounts of genetic information on large numbers of individuals means that someone coming from a mathematical and statistical background has a potentially central role to play in developing sophisticated statistical tools to make sense of the data. Some of my papers which have had the biggest impact introduce statistical methods for answering scientific questions based on these sorts of data.

Thus, I have evolved from a young scientist with mathematical and statistical expertise to someone who runs an experimental lab. On the way I have learnt quite a bit of science, from evolution and population genetics through to human disease and the molecular biology at the centre of sexual reproduction. It has been a fantastic journey!

With some colleagues you founded genomics plc and, since May 2017, you have become its Chief Executive Officer. What motivated you to this move?

I became passionate about human genetics because I saw it as one of the keys to a deeper understanding of human biology, leading in turn to improving medicine and healthcare. After 20 years of leading the cutting-edge studies, and creating the largest databases, I became frustrated that the huge advances in the science weren't yet being translated to have a big impact on the lives of patients. With some colleagues in Oxford, we decided we needed a fresh approach, and to tackle this head-on, so we brought together some of the best and brightest in the field and organised them as a start-up to put their brains towards translation and creating real value for patients and healthcare systems. Genomics can provide powerful tools for identifying subsets of individuals at substantially increased risk across each of the common human diseases. This in turn offers the potential for "prevention first" in healthcare, where the focus is on keeping people healthy, and detecting disease early when it is often much simpler to treat. Instead of managing and ameliorating late-stage disease, we have the chance to keep people out of the healthcare system by keeping them well. In parallel, genetic approaches can transform a drug development industry which is effectively broken: currently 90% of novel drug targets taken into clinical trials in humans fail. Our company is about to embark on substantial collaborations within the UK National Health Service, and a number of other healthcare systems, and we are already working with some of the leading pharmaceutical and biotech companies.

There are a whole set of new and really interesting challenges in running a start-up, or in our case not-so-start up (we have 70 people spread between Oxford and Cambridge in the UK, with an office likely in the US later this year), from recruitment, team structure, scientific research, raising capital, to commercial strategy and finally delivering products. I'm loving it!

Most of my daily work now is about running the company, thinking about strategic issues. That is a long way from statistics and probability but there is still a connection. The company is fundamentally science driven and is about bringing together and then analysing massive genetic datasets. Statistical approaches and machine learning are central to what we do as a company. My role is at a relatively high level but I think it is very helpful that I can understand the technical work, and occasionally contribute to it.

One interesting, and in some ways surprising, difference between academic research and research in a company is that in a company the research is often much more collaborative and much more team-based than the academic world. In academia, especially in the biomedical sciences, individuals are often racing to publish first, competing for grants, and pushing for tenure and then promotions. Statistics is perhaps less cutthroat than other areas of science, but it is still very competitive.

Do you have any careers advice for early career researchers?

I think in many ways it is not such an easy time to be starting an academic career. There are also many more attractive options for research in the commercial sector, in the tech companies, and in many other organisations from large pharmaceuticals and biotechs to small start-ups. But either way, the power and the potential for statistical approaches to make a huge difference on really important questions, across most fields is huge. Data science is a trendy term, and the area has a lot of overlap with statistics, but it is indicative of a growing set of opportunities for impact, and recognition of the importance of statistical skills.

Some in our field enjoy applications because they lead to interesting statistical questions. But there are others who get hooked on the application area and become driven by that. My journey took me from one side to the other. I would encourage researchers to pursue the application of their work if they really care about it, because it is easier to make a big difference if you really understand the area, and can judge which questions, amongst many, are really important. I've learnt that in science there is a real skill in being able to identify the right questions – it may even be more important than solving them. A lot of really high-quality statistical work has less impact than it might simply because it is directed at the wrong questions.

Any last thoughts?

I do feel incredibly lucky. I have absolutely loved what I've been doing at every stage of my career: from applied probability, through computational statistics to population and statistical genetics and the genetics of human diseases, then to the molecular biology of meiosis and now to running a company that has a chance of transforming healthcare. What I have been doing has evolved, but at every stage I felt that what I was doing was even more exciting than what I used to be doing! A key part of what I have learned of myself is that I work best when I am interacting with people and collaborating. I have been very fortunate, not just with the scientific calibre of those I've been able to work with, but also the human side – the friendships and shared times which have so enriched my life.

An Interview with Wilfried Kendall

Tuesday 28th January 2020, at the University of York
Interviewer: Stephen Connor

Wilfrid Kendall is Professor of Statistics at the University of Warwick. During the last 40 years he has written over 80 papers on a variety of topics in applied probability, most notably in topics relating to probabilistic coupling, perfect simulation and stochastic geometry. In addition, he has played important roles within the probability and statistics community: he was the co-founder of the Academy for PhD Training in Statistics (APTS), which for the last 13 years has provided fundamental training courses for first year PhD students across the UK; in 2011 he helped to found the Applied Probability Section of the Royal Statistical Society; and from 2013-2015 he was president of the Bernoulli Society.

When did you get interested in probability and statistics? Was this something you always knew that you wanted to do?

I wanted to do mathematics at 17, because I suddenly discovered I could do it and it just seemed very cool. It was really quite exciting to discover there was actually something I could do! Then I went to Oxford, which was at that stage a centre of beauty and abstraction in mathematics, and that was very stimulating but I don't think I ever thought of myself as particularly interested in probability or statistics. After all, my father (David Kendall) did that and so the subject was a "be careful" zone.
Then I started doing a PhD: my supervisor was John Kingman, who in a sense was supervised by my father, except that Kingman never got around to finishing his PhD. (So my father is almost my academic grandfather!) I'd planned a PhD in functional analysis, but it seemed that every remotely interesting question in functional analysis either didn't interest me or was incredibly difficult. At the same time my father mentioned a couple of interesting applied probability questions, which I could solve. People who knew me advised that it's really quite difficult being in the same profession as your father, but nevertheless I ended up doing more and more probability and discovered – quite late – that I really did enjoy it very much.

You went from Oxford straight into a lectureship in Hull?

Indeed! At that time, academic job prospects looked dire. Plenty of people kindly advised me that I shouldn't try to have an academic career because for ten years it was going to be very difficult and hard to make your way, so if I had any sense I had better find something else to do. But I didn't have any sense at all, so I persisted. I managed to get a lectureship in statistics at Hull, and the joke was that this was the last job in probability or statistics for the next five years – that's not quite true, but it felt like it at the time.
There were lots of positives about Hull – it was a very friendly department and I was very well supported. There were other bonuses too. After a somewhat unpromising early start I suddenly ran into this charming delightful person who ended up as my wife. So we always speak of Hull as a city of romance and excitement ...

From Hull you moved to Strathclyde: what was the motivation there?

Brian Ripley was at Strathclyde, a major figure in spatial statistics. At that time, spurred on by my father, I'd undertaken a collaborative book project with a couple of East Germans, Stoyan and Mecke. They'd already written a short handbook on stochastic geometry, and I was brought in to contribute a chapter or two, and to work through everything to make sure it was in English. That was quite an ordeal! At the time if you wanted to type up mathematics, then you either had to have legible handwriting so a secretary could read it, or you had to have access to some kind of mathematical word processor. So my first year of married life was challenged by the fact that I had to get into work by 8 o'clock each morning to have an hour on the mathematical word processor before the secretaries got in, and then a couple of hours at the end of the day after they'd gone, and then come home late. Another complication was that it was very difficult to have much contact with my co-authors because they were in East Germany. I managed to go over to talk to them a couple of times, but there was no question of them being able to come and see me. But eventually through relentless effort we managed to produce the book (Stochastic Geometry and its Applications). I had very mixed feelings when it arrived! "Thank goodness it's out", but also the thought of all that work made it very difficult to be in the same room as the book for a while! However, in the end, many people kindly refer to the book a lot and indeed as the years go by I myself refer to it more and more for things that I want to do and ideas I want to use.

You've been at Warwick since 1988. What changes have you seen during your time there?

I think there were only eight full time members of staff back then: now we have nearly 60. So a few changes have happened!
Coming to Warwick was amazing. Everyone was very good academically but, much better still, everyone was very interested in ideas. Previously, I had tended to be in departments where people would say, "That thing

you thought of, what use is that?" – sometimes quite an adversarial reaction, a bit difficult to deal with. At Warwick people said, "That's fascinating, tell me more about it just in case it's something I could find useful". Very positive. And many people were passing through, both in statistics and mathematics, so a lot of stimulation.

It was very informal when I arrived: with eight people you didn't have to do workload calculations – jobs which needed doing were shared out. It's very different in a department of 50+, and it has to be run in a different way. However, if I make a real effort to compare with how it felt in other universities before I moved to Warwick, it's still an extraordinarily different place. There's something very special about being involved in the nurturing of an academic community, and it has been a real privilege to be involved in that.

Let's talk about some of your particular research interests. Coupling has been central to a lot of your work: what's your favourite result which can be proved elegantly via a coupling argument?

I'd go back to my very first engagement with coupling. In 1980 I made a three month visit to CSIRO in Australia, and I worked there with Ian Saunders. He posed a problem arising from the consideration of myxomatosis in rabbits. Rabbits are a real pest in Australia, and there were two kinds of myxomatosis: one essentially killed them, and the other they could recover from, and the two kinds conferred cross-immunity. Ian had written a paper about this, but he got stuck upon whether there was a certain kind of monotonicity: if you increased the number of infectives of one kind at the expense of the other, would you get a corresponding increase in the number of rabbits eventually catching that particular version of the disease? His approach was based on differential equations, and we looked at this and puzzled about it. I realised that if you think of the rabbits as individuals, rather than a continuum, then some of the arguments we were trying to make suddenly became a lot more natural. And it turned out there is a monotonicity here when you look at this differential equation formulation as the limit of a stochastic model based upon individual rabbits. That was very cool, because this method was telling us something that we'd tried really hard to get in the continuous world, and simply hadn't been able to do. After that, I started seeing coupling everywhere (and of course it is everywhere)!

What's still left to discover about coupling?

Well I think there's always going to be something to be discovered about coupling: viewed very abstractly, you're just taking a stochastic system and thinking of a different way to construct that system in which some questions become much easier to answer. That's not going to go out of fashion.

There are some foundational questions, which attract me a lot. It's well known that, quite remarkably, when you want to couple two random processes you can do that in such a way that they have maximal chance of meeting by any time you care to mention. The classical example here is reflected coupling of Brownian motions, and that coupling is actually a Markovian coupling. (Neither trajectory looks ahead to see what the other is going to do.) But then the generic constructions of maximal couplings involve looking ahead into the future (and we know of concrete examples in which you simply can't expect to get a maximal coupling without looking ahead). So the question is: where's the boundary here? What sorts of process can you couple maximally without one trajectory looking ahead to see what the other's going to do? With Sayan Banerjee a couple of years back we discovered, at least in the category of elliptic diffusions with smooth coefficients, that we can say exactly when you can do that: it's when the underlying geometry of the diffusion has constant curvature, and when the vector field which is the intrinsic drift of the diffusion is given either by an underlying symmetry of the space or a dilation.

I think there's a lot more of that sort of thing to do. In particular, maximal coupling is probably too much to ask for. When can you say something sensible about when there is a coupling which is as good as you could possibly expect to get using only Markovian couplings (what you might call an optimal Markovian coupling)? And we know just enough examples to know that that's a very non-trivial sort of question: sometimes there is one, sometimes there isn't. Those are foundational questions about coupling, and they are just barely beginning to be explored.

Perfect simulation kicked off in the 1990s, and you were involved from relatively early on. How did you get into this area?

It was Adrian Baddeley's fault. I went to a conference at CWI Amsterdam which he was running with Marie-Colette van Lieshout, and Julian Besag in great excitement told us about this brilliant new idea by Propp and Wilson, called Coupling from the Past (CFTP). Adrian said to me, "Can you do this for generating point processes as equilibria of birth death processes?". So that started me off, and the answer turned out to be yes, but you needed to invent a new kind of CFTP called dominated CFTP. The original CFTP requires the chain you're looking at to be uniformly ergodic, which is quite a tight restriction; certainly in spatial statistics it doesn't usually hold, and so you need to extend the idea. That's dominated CFTP, and my first paper in the area showed how to implement this for the area interaction process.

Perfect simulation is often difficult to sell to practitioners who are used to MCMC. Do you think that people should be more willing to consider using perfect simulation algorithms in practice?

I don't believe I ever thought that perfect simulation was going to be the answer to everything, and from early on my view was that the important thing about it is that it's a new way to think about doing MCMC, and it's always helpful to have a different perspective. MCMC in general simply isn't a universal nostrum: if you have a problem and you're trying to apply MCMC to it then you want to have as much information as you possibly can about the underlying thing you're trying to investigate, in case any of it gives you clues to speed up the algorithm, or at least gives you some idea of how well it's converging. So that's where CFTP fits in, in my view – it's saying something about how MCMC can behave. What I've been noticing, particularly at Warwick, is a number of people are now using CFTP and exact simulation techniques in complex problems arising from big data because it's important for them in these very modern perspectives – there's a bit of a resurgence of interest in CFTP because of that.

More recently you've been involved in applying stochastic geometry to problems arising in archaeology and engineering.

With Clair Barnes (a Masters student at Warwick) I helped archaeologists who were trying to understand whether there is evidence that Anglo-Saxon builders of the 8th century used a common unit of measurement in building large stone structures from as far down as the south of England right up to Northumberland. It turns out that there is, and you will soon be able to read about this in an appendix in a book by John Blair on Anglo-Saxon construction in the early medieval landscape.
On the engineering side of things, one of the projects in which I've been involved looks at patterns of dysfunctional pixels on display screens, typically in high-energy environments like X-ray detection. We've now developed an online web app which allows people to upload test screens from their X-ray machines and assess whether there is evidence for pattern in the arrangement of dead pixels on their screen. We're hoping to build this into a data collecting project, where we can look at whether these dysfunctional pixels can be seen to be evolving in time. Certainly as you use the screen more, more of these appear and the question is "Each pixel that goes wrong, does it go wrong in interesting ways?". These screens cost a lot of money to refurbish: it would be good to have an evidence base for how often you expect to have to do that, and to understand whether there may be different ways of treating machines which make them more or less prone to damage.

You've had significant involvement in supporting the wider research community over the years. In particular, you were one of the co-founders of APTS: can you tell us how this programme came about?

EPSRC decided that it wanted more generic skills training for PhD students, and one of the ways it was going to do this was to fund what they called Taught Course Centres. David Firth and I both thought it would be a real shame if some of the money they were making available didn't come to statistics, so we got together a group from various universities in the UK and we brainstormed what we would actually need to do if we were to run something which wouldn't just meet the criteria for EPSRC, but would be a real help for the UK community. We came up with the APTS proposal – 4 intensive residential weeks of training for first year PhD students in statistics – and we successfully sold it to EPSRC. We opted for a residential scheme as we didn't trust modern technology to develop anything significantly better than what you get face-to-face, and we thought that there were major networking values in getting people together.
We spent a year planning it and then ran our first APTS series. It was a runaway success from the word go, and has just been going on getting better. I think that first year's planning was probably crucial to that, because we spent a considerable amount of time deciding exactly what we wanted to do, and it's changed remarkably little over the years. It was an amazing privilege to be involved right from the beginning.

What were the main challenges in setting up something of this scale?

Whenever you have a significantly large bunch of people going through something, there are lots of exceptional cases which have to be dealt with rationally and fairly: getting a structure where the responses to the various questions which came up were pretty much automatically in the rules was really important, and much amount of attention was spent on that. A lot of effort was spent getting the constitutional structure right, so that APTS wasn't just some bright idea owned at Warwick, but was something that everybody felt that they owned. And I think that we've achieved that. I'm optimistic about the future of APTS: I think it's something that everybody wants to see carrying on.

You have a strong family tie to the Bernoulli Society: your father was its first president, and you were president from 2013-15.

Yes, my father was part of the group who set up the society, and he became the first Bernoulli Society president. Much of the history of the society can be found on the web. He established a tradition where every Bernoulli president wrote their name in order in a book which was a German history of the Bernoulli family. His name is on the top of the first page, and now my signature is on the top of the second. And who knows? There is at least one Kendall family member who's at the start of their statistical career, so who knows what will happen at the top of the third page...!

What were your main contributions during your time as president?

Well I didn't break the Bernoulli Society! My predecessor, Ed Waymire, was asked "What's your vision for the society" and he said "Not to break it!", and I think there's a lot to be said for that sort of attitude. I had to organise the writing of a new constitution, because the Bernoulli Society runs under Dutch law, and when Dutch law changes the constitution has to reflect that. Every now and then some unlucky president has to be the one who deals with the process of developing a new constitution, and that fell to me.

Practically everything that happened was at least co-operative and quite often someone else's idea – that's just the nature of things. I helped to push the idea of having receptions for young scientists at various conferences, and to try to institutionalise the idea of running a pre-meeting for young scientists before a Bernoulli Society meeting (building on the really good pre-meeting for the 2005 EMS in Oslo, organised by Arnoldo Frigessi). There's still a significant and tricky question of how to finance that, but it's now understood to be part of the things that we'd like to do.

Do you think it's important for mathematicians to become members of professional societies?

Yes, because societies make happen a significant proportion of the opportunities for publishing, and an even more significant proportion of the opportunities for meeting in conferences. It's important to have ownership of that, since these are in effect our means of production. If they were wholly owned by someone else, some government organisation or some commercial publisher, then we would be on our way to becoming wage slaves – we would have to do what other people told us to do. And if they're going to be run by our community then we individually need to engage to make that happen. By contributing to helping run a society you're actually going to be meeting people who you're going to spend the rest of your life working with. These societies are vital to our individual professional happiness, so we need to make sure that they're really going well; we all need to join in.

And finally. What do you see as being some of the big things in probability theory over the next 10-20 years? Where's the field going?

Well I know that's what someone of my age is traditionally supposed to be able to answer, but I'm far too young to be able to give a good answer, so I'd suggest you come back in ten years' time!

I'm really grateful for having been so fortunate as to have more than 40 years in this subject – a lot of my contemporaries never got that chance. It has been really stimulating and interesting, and it goes on being so. I think the other thing that strikes me very much about this subject is that you make lots of friends. Now, within this area you might think "Why wouldn't you say that?", but if you look across science you see that other areas are marked not by strong friendships but by bitter enemies, and we should be grateful that probability is, by and large, a friendly subject. Let's make sure we keep it that way.

Articles and Letters

Cardy embedding of random planar maps

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Communicated by the Editor

This article summarizes ideas from the *Bernoulli New Researcher Award 2020*. Random planar geometry has been an important topic in probability theory for the past twenty years. In particular, two natural models for random surfaces have been studied: random planar maps (RPM) and Liouville quantum gravity (LQG). We present a recent work of the author and Xin Sun which proves convergence of a uniformly sampled RPM to LQG under a discrete conformal embedding called the Cardy embedding. It is also proved that critical percolation on the RPM converge to the conformal loop ensemble (CLE) with parameter $\kappa = 6$ in a quenched sense.

A random planar map (RPM) is a natural model for a discrete random surface which has its roots in the combinatorics literature in the 60s. Later it has been studied also in e.g. physics, geometry, and probability theory. Liouville quantum gravity (LQG) is a model for a continuum random surface which has its roots in string theory and conformal field theory from the 80s and 90s.

In the physics literature both RPM and LQG are used as models for quantum gravity. Heuristic calculations suggest the equivalence of the two models, e.g. at the level of exponents. This leads to mathematical conjectures that RPM converge in the scaling limit (in some topology) to LQG. In recent years several rigorous results have been established in the mathematics literature that relate RPM and LQG. We present some of these results, with particular emphasis on a recent result of the author and Sun [11], which is a first scaling limit result for uniform RPM under a discrete conformal embedding. The embedding is defined using percolation observables on the planar map and we call it the *Cardy embedding*. See Theorem 1.

A RPM defines a random geometry. By universality, it is believed that many lattice models which have conformally invariant scaling limits on regular lattices also have this on the random lattice defined by a RPM. One example of such a model is percolation. Recall that Smirnov proved conformal invariance of critical site percolation on the triangular lattice [18], and that this implies convergence of the percolation cycles on the lattice to the so-called *conformal loop ensemble* (CLE) with parameter 6 [3]. As a byproduct of our convergence proof for RPM under the Cardy embedding, we get conformal invariance of critical site percolation on the RPM. We prove convergence of the percolation cycles to CLE_6 in a quenched sense, i.e., conditioned on the randomness of the RPM. See Theorem 2.

§1. Random planar maps and Liouville quantum gravity

A planar map is a finite connected graph embedded into $\mathbb{R}^2$ so that no two edges cross. Two planar maps M_1 and M_2 are considered to be equivalent if there is an orientation-preserving homeomorphism $\phi : \mathbb{R}^2 \to \mathbb{R}^2$ which sends M_1 to M_2. A planar map is a *triangulation* if all faces have exactly three edges. We consider type II triangulations, which means that we allow multiple edges between a pair of vertices, but we do not allow self-loops. A planar map is called a *triangulation of a disk* if all faces have exactly three edges except for the exterior face (i.e., the face containing ∞), which has arbitrary degree (called the *perimeter*) and simple boundary. See Figure 1. Given a perimeter $p \in \{2, 3, \dots\}$ there is a particularly natural probability measure on triangulations of a disk called the *Boltzman measure*. This measure gives mass proportional to $(2/27)^n$ to each fixed triangulation of a disk with perimeter p and n vertices.

Let $(B_t)_{t\in[0,1]}$ denote a Brownian bridge satisfying $B_0 = B_1 = 0$. The 2D *Gaussian free field* (GFF) is the natural generalization of this process to the case of two time dimensions, i.e., the process is indexed by $t \in D$ (instead of $t \in [0, 1]$) for $D \subset \mathbb{C}$ a planar domain. It turns out that the 2D GFF is not well-defined as a random function, but rather it is a random generalized function or distribution. The 2D GFF is almost surely an element of the Sobolev space $H^{-\epsilon}(D)$ for any $\epsilon > 0$. Assuming D has a harmonically non-trivial boundary, the zero-boundary 2D GFF can be uniquely defined by requiring that for any smooth compactly supported function $f : D \to \mathbb{R}$, (h, f) is a centered Gaussian with variance $\int_D f(x)G(x, y)f(y)\, d^2x\, d^2y$, where $G : D \times D \to \mathbb{R}$ is the zero-boundary Green's function on D. The Gaussian free field arises as the scaling limit of a number of functions appearing in statistical physics.

Let $\gamma \in (0, 2)$. Liouville quantum gravity (LQG) is the study of random surfaces which can be written heuristically on the form $e^{\gamma h}(dx^2 + dy^2)$, where h is an instance of the 2D GFF or a related kind of distribution, while $dx^2 + dy^2$ is the standard Euclidean metric. Since h is a distribution and not a function it is not clear how to make rigorous sense of this surface.

However, it is not difficult to show that the area measure associated with the surface can be defined in a rigorous way. Let h_ϵ denote some regularized version of h, e.g. $h_\epsilon(z)$ denotes the average of h on the circle $\partial B_\epsilon(z)$ of radius ϵ centered at z. Then h_ϵ is a continuous function which can be used to define a measure $d\mu_\epsilon = \epsilon^{\gamma^2/2} e^{\gamma h_\epsilon} d^2 z$. This measure μ_ϵ converges almost surely and in L^1 towards some limiting measure μ as $\epsilon \to 0$. See e.g. [15, 5]. The $\sqrt{8/3}$-*LQG disk* is a particular type of $\sqrt{8/3}$-LQG surface which has the topology of a disk and finite total area, and it plays a special role since it describes the scaling limit of certain RPM.

In recent years, there has been a great interest among mathematicians in establishing rigorous relationships between RPM and LQG. The first scaling limit result for RPM was established by Le Gall [12] and Miermont [13]: They proved that uniformly sampled quadrangulations equipped with the graph distance converge in the scaling limit as metric spaces to a limiting random metric space known as the *Brownian map*. The topology of convergence is known as the Gromov-Hausdorff topology. Viewing the planar map as a metric measure space by giving the vertices unit mass, one can further prove convergence for the Gromov-Hausdorff-Prokhorov topology. The scaling limit result for quadrangulations was later extended to other uniform RPM models, including RPM with other topologies. The case of triangulations of a disk are of particular interest to us [1].

The Brownian map is a random surface which is equipped with a metric and an area measure. LQG also defines a model for a random surface, but, besides having an area measure, it also has a conformal structure. Miller and Sheffield proved that these two natural models for random surfaces are equivalent when $\gamma = \sqrt{8/3}$ [14]. LQG with $\gamma = \sqrt{8/3}$ plays a special role in the physics literature and is often called *pure* quantum gravity. Via a growth process known as the Quantum Loewner evolution Miller and Sheffield proved that one can construct a metric on a $\sqrt{8/3}$-LQG surface such that the resulting metric measure space is equal in law to the Brownian map. Furthermore, the original LQG surface is determined by (i.e., is measurable with respect to) the resulting metric measure space. Convergence of planar maps to γ-LQG (for a range of different γ-values) has also been established in the so-called peanosphere topology, see e.g. [4, 17].

Beside convergence in metric and peanosphere topologies, there is a third notion of convergence one can consider: convergence under conformal embedding. This is maybe the notion of convergence which is closest to the original physics papers, and is the topic of the next section.

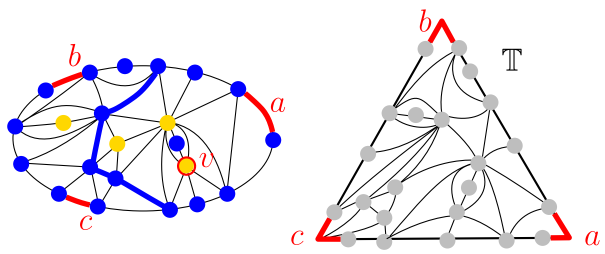
§2. The Cardy embedding

Recall that a planar map is defined to be an embedded planar graph, but that the embedding is only defined modulo continuous deformations. However, there are several natural ways to fix the embedding. For several of these embeddings, one can argue at least heuristically that the embedding approximates a conformal map. Such discrete conformal embeddings are of interest when viewing a RPM as a discrete model for LQG.

Examples of such discrete conformal embeddings include circle packings, the Tutte embedding, square tilings, and embedding via the uniformization theorem for Riemann surfaces. We will study a fifth discrete conformal embedding, namely the Cardy embedding. This embedding, which was introduced in [11], is inspired by Smirnov's proof of Cardy's formula. Given a triangulation of a disk M with three distinct boundary edges a, b, c ordered counterclockwise, we denote by (a, b) the set of boundary vertices of M situated between a and b in counterclockwise order (including one endpoint of a and one endpoint of b). Define (b, c) and (c, a) similarly. Let $\omega : \mathcal{V}(M) \to \{\text{yellow, blue}\}$ be a coloring of M such that the boundary vertices are blue and the interior vertices are colored uniformly and independently at random in yellow and blue. For a vertex $v \in \mathcal{V}(M)$, let $E_a(v)$ be the event that there exists a simple path P on M such that

(a) P has one endpoint in (c, a) and one endpoint in (a, b), while all other vertices of P are inner blue vertices;
(b) either $v \in P$ or v is on the same side of P as the edge a.

We define the events $E_b(v)$ and $E_c(v)$ similarly.



Left: Illustration of the event $E_a(v)$. Right: An embedding of M into Δ.

Consider the equilateral triangle $\Delta := \{(x, y, z) : x + y + z = 1,\ x, y, z > 0\}$ and let $\overline{\Delta}$ denote its closure. The Cardy embedding of (M, a, b, c) is the function $\text{Cdy}_M : \mathcal{V}(M) \to \overline{\Delta}$ given by

$$\text{Cdy}_M(v) = \frac{(\mathbb{P}_M[E_a(v)], \mathbb{P}_M[E_b(v)], \mathbb{P}_M[E_c(v)])}{\mathbb{P}_M[E_a(v)] + \mathbb{P}_M[E_b(v)] + \mathbb{P}_M[E_c(v)]}.$$

Smirnov showed that if we apply the Cardy embedding to the triangular lattice restricted to some simply connected domain D for which ∂D defines a continuous loop, then we approximate the Riemann mapping from D to $\mathbb{T}$. Conformal invariance of percolation is an immediate consequence of this result.

The embedded planar map defines an area measure μ_n and a (pseudo)metric d_n in $\overline{\Delta}$ as follows. If M has perimeter p we define $n = p^2$ and for any set $U \subset \overline{\Delta}$ we define

$$\mu_n(U) = n^{-1} \cdot \#\{v \in V(M) : \mathrm{Cdy}_M(v) \in U\}.$$

In other words, we give each embedded vertex mass n^{-1}. For $x \in \overline{\Delta}$ let $\mathfrak{v}(x) \in V(M)$ be such that $\|x - \mathrm{Cdy}_M(\mathfrak{v}(x))\|$ is minimized. Let $d^{\mathrm{gr}} : V(M) \times V(M) \to \mathbb{N} \cup \{0\}$ denote the graph distance and for $x, y \in \overline{\Delta}$, define

$$d_n(x, y) = n^{-1/4} \cdot d^{\mathrm{gr}}(\mathfrak{v}(x), \mathfrak{v}(y)).$$

Let μ denote the area measure of a $\sqrt{8/3}$-LQG disk with perimeter 1 embedded into Δ and let d denote the associated $\sqrt{8/3}$-LQG metric. The following theorem gives convergence of uniform triangulations of a disk under the Cardy embedding, where we use $\Rightarrow$ to denote convergence in law.

Theorem 1. *There exist deterministic constants $c_1, c_2 > 0$ such that $(c_1\mu_n, c_2 d_n) \Rightarrow (\mu, d)$, where we equip the first coordinate with the weak topology and the second coordinate with the uniform topology.*

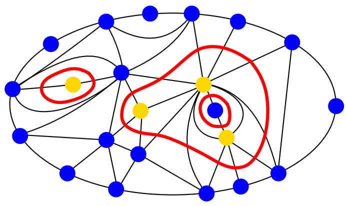
We remark that one can obtain convergence of uniform triangulations with other topologies (e.g. whole-plane or sphere) by modifying the definition of Cdy_M appropriately. Furthermore, Theorem 1 also holds for triangulations where we allow self-loops or do not allow multiple edges since these can be coupled to type II triangulations.

§3. Quenched convergence of percolation on uniform triangulations

The Schramm-Loewner evolution (SLE) is a family of random fractal curves which describe the scaling limit of interfaces in statistical physics models. They were discovered by Schramm [16] and are uniquely characterized by two properties: conformal invariance and the domain Markov property. The conformal loop ensemble of parameter κ (CLE_κ) is a loop version of SLE_κ which describes the full collection interfaces in the discrete model, rather than a single interface.

Recall that Smirnov proved conformal invariance of crossing probabilities in critical site percolation on the triangular lattice, and that this implies convergence of a single percolation interfaces to SLE_6 and of the full collection of percolation interfaces to CLE_6. By universality, it is believed that critical percolation on a wide range of lattices should have conformally invariant scaling limits. There have been attempts to extend Smirnov's result to percolation in other settings, for example the case of bond percolation on $\mathbb{Z}^2$ and face percolation on a Voronoi tesselation. However, it is challenging to adapt Smirnov's proof technique since he used particular combinatorial identities which are only available for the triangular lattice.

In the case of random triangulations, however, it is possible to prove a new convergence result for critical percolation interfaces to SLE_6 and CLE_6. Let M be a Boltzman triangulation of a disk with fixed perimeter p. We also assume M has three marked boundary vertices a, b, c which are chosen uniformly at random. For some k consider independent percolations $\omega_1, \dots, \omega_k$ on M. We view $(M, \omega_1, \dots, \omega_k)$ as a metric measure space decorated by k loop ensembles. A loop ensemble is a countable collection of loops and we consider two loop ensembles ω and ω' to be close if, for any loop in ω (resp. ω') there is a loop in ω' (resp. ω) which is close for the uniform topology modulo reparametrization of time. We call the resulting topology on tuples $(M, \omega_1, \dots, \omega_k)$ the *Gromov-Hausdorff-Prokhorov-Loop* (GHPL) topology.



The percolation cycles converge to CLE_6.

Theorem 2. $(M, \omega_1, \dots, \omega_k) \Rightarrow (\mathcal{S}, \Gamma_1, \dots, \Gamma_k)$ *in the GHPL topology.*

Theorem 1 is an almost immediate consequence of this result: Crossing events in the discrete (resp. continuum) are encoded by the ω_j's (resp. the Γ_j's). Using this and Theorem 2, we know that the conformal structure of M can be studied by considering empirical crossing statistics for $\omega_1, \dots, \omega_k$ with k large, since, by Theorem 2, these match the crossing statistics for $\Gamma_1, \dots, \Gamma_k$, which reflect the conformal structure of $\mathcal{S}$.

Theorem 2 can be viewed as a quenched convergence result for percolation on RPM. Earlier annealed results were proved in [7, 8]. In particular, [8] proves convergence of (M, ω_j) in the GHPL topology for each fixed $j \in \{1, \dots, k\}$. Building on this result, in order to prove Theorem 2 it remains to prove independence of $\Gamma_1, \dots, \Gamma_k$ in any subsequential limit of $(M, \omega_1, \dots, \omega_k)$. This is done by studying the scaling limit of so-called *dynamical percolation* on a RPM. In dynamical percolation, each vertex of the RPM has an independent Poisson clock (i.e., a random clock which rings at the set of times given by a Poisson point process) and the color of the vertex is resampled every time its clock rings. The continuum analogue of dynamical percolation is a dynamically changing CLE_6, and we call this process *Liouville dynamical percolation* [6]. The so-called pivotal points of the percolation, which are studied in [2, 9, 10], play a key role for the process. Independence of $\Gamma_1, \ldots, \Gamma_k$ is deduced from a mixing result for Liouville dynamical percolation.

Finally, we remark that Theorems 1 and 2 are special cases of a result which is believed to hold in much greater generality. More precisely, the results are still conjectured to hold if we make one or more of the following changes. Substantial new ideas are needed to prove the more general variants.

(1) We change the law of the RPM M, for example we apply other local constraints (e.g., the map is a quadrangulation, simple map, etc.) or the law of the RPM is reweighted by the partition function of some statistical physics model on the planar map. The reweighting will typically have the effect of changing the parameter γ of the LQG surface.

(2) In Theorem 1 we can consider another embedding, such as a circle packing or embedding via the uniformization theorem. We can also define other embeddings in the spirit of the Cardy embedding where we use observables of other critical statistical physics models than percolation.

(3) In Theorem 2 we can obtain CLE_κ with other κ values by considering other critical statistical physics models which are proven or believed to have conformally invariant scaling limits on regular lattices, such as the Ising model, the FK model, or the uniform spanning tree.

Acknowledgement. The author was supported by Dr. Max Rössler, the Walter Haefner Foundation, and the ETH Zürich Foundation.

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Past Conferences, Meetings and Workshops

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32nd EMS: July 22-26, 2019; Palermo, Italy


The 32nd European Meeting of Statisticians was held in July 22-26, 2019 in Palermo. The European Meeting of Statisticians (EMS) is the main conference in statistics and probability in Europe. The very first EMS meeting was held in Dublin in 1962. The meeting was co-sponsored by the European Regional Committee of the Bernoulli Society, the University of Palermo, the University of Cagliari, the Polytechnic University of Turin, the University of Trieste and the Italian Statistical Society (SIS), and hosted by the Department of Economics, Business and Statistics, on the campus of the University of Palermo.

The 32nd edition of the European Meeting of Statisticians put together recent advances and trends in several fields of statistics and probability theory, which spanned a broad range of topics from probability, finance, statistics, and biostatistics. With 6 plenary speakers, 25 invited sessions, 20 topic-contributed sessions, 35 contributed sessions and a poster session, and with about 450 participants, EMS19 is the perfect place to exchange ideas and promote collaboration between researchers from all the World.

The scientific program included plenary lectures by Judith Rousseau (Oxford University), *Bayesian measures of uncertainty on high or infinite dimensional statistics*; Genevera Allen (Rice University), *Data integration: data-driven discovery from diverse data sources*; Victor Panaretos (Ecole Polytechnique Federale de Lausanne), *Amplitude and phase variation of random processes*; Aad Van der Vaart (University of Leiden), *Nonparametric Bayes: review and challenges*; Gilles Blanchard (University of Potsdam) *A general framework for resource-efficient large-scale statistical learning by data sketching*; John Lafferty (Yale University), *Computational perspectives on some statistical problems*. There were many other memorable talks, and participants remarked on the high quality of the science and the stimulating discussions they encountered (facilitated by the excellent refreshment during the coffee breaks). Details may be found at `https://www.ems2019.palermo.it`.

The 32nd EMS was a collective effort and many individuals and organizations have contributed. The Programme Committee, the Local Organizing Committee, the organizers of the Invited Sessions, the local hosting university and volunteers, all of them have played to a substantial role in the organization of the meeting. We warmly acknowledge their work and the support of all the institutions and organizations that have sponsored the meeting. The social dinner event took place at "Castello a mare", one of the most historically rich areas of the city center of Palermo. The weather was beautiful, and participants were rewarded with good company and beautiful views of the city. The organizers have received many very positive reactions by the participants during the workshop. The high scientific content of the program was praised, as well as the facilities of the University of Palermo and the very helpful assistance by the staff.

Angelo Mineo
Chair of the Local Organizing Committee
Palermo

CLAPEM 2019: December 2-6, 2019; Mérida, Yucatán, México

The Congreso Latinoamericano de Probabilidad y Estadística Matemática (CLAPEM) is the official meeting of the Sociedad Latino Americana de Probabilidad y Estadística Matemática (SLAPEM), the Latin American Regional Chapter of the Bernoulli Society. It is the major event in Probability and Statistics in the region and it gathers an important number of researchers and students, predominantly from Latin America. It serves as a forum to discuss and to propagate recent advances in the field, as well as to shape the future of our profession.

The XV CLAPEM gathered more than 300 partici-

 

pants in Mérida, the capital city of the Mexican State of Yucatán. Two thirds of them acted as speakers in a wide-ranging program consisting of four plenary and six semi-plenary talks, as well as 21 contributed and 10 thematic sessions incorporating two courses and 72 contributed talks.

CLAPEM's high-profile program included the following plenary lectures by Sourav Chatterjee (Stanford University), *Average Gromov Hyperbolicity and the Parisi Ansatz*; Thomas Mountford (EPFL, Switzerland), *Invariance Principles for Markov Cookie Random Walks*; Judith Rousseau (University of Oxford), *Estimating the Interaction Functions and the Graph of Interactions in Multivariate Hawkes Processes using Bayesian Nonparametric Methods*; and Gerard Ben Arous (Courant Institute), *Kac-Rice in Very High Dimensions: from Physics to High Dimensional Statistics and Machine Learning*.

Semi-plenary speakers addressed a broad scope of topics, from Bayesian statistics to Poisson processes and random partition models. These speakers were Lea Popovic (Concordia University), Fernando Quintana (Pontificia Universidad Católica de Chile), Chris Holmes (Oxford University), Jean Michel Jarin (University of Montpellier), Pablo Ferrari (Universidad de Buenos Aires), and Michele Guindani (University of California, Irvine).

Professor Florencia Leonardi, President of the Latin American Society for Probability and Statistical Mathematics (and Latin American Regional Chapter of the Bernoulli Society, LARC-SLAPEM), said: "I am very surprised, for the better; it has made me very happy to arrive in Mérida and see so many participants; I think this was very well organized and programed (...) ; I think there is a very good balance between Probability and Statistics, and the quality of the Congress has been very good." She believes that the program, in her field has been "on the highest level of the work done globally; of course there have been some topics left out, but that is always normal."

The presence of young researchers and graduate students gave this edition a special feeling, and different researchers noticed the enthusiasm of the future probabilists and statisticians. According to Professor Florencia Leonardi, it is very positive to engage students from within the country that hosts each CLAPEM's edition, as foreign students struggle to find financial support to travel abroad. Local students represent future generations and the opportunity to incorporate new ideas.

Daniel Hernández Hernández
Chair of the Organizing Committee
Guanajuato

Probabilistic Coupling and Geometry Workshop: December 9-10, 2019; Coventry, UK

 

A Workshop on Probabilistic Coupling and Geometry was held on 9th-10th December 2019 at the University of Warwick to mark Professor Wilfrid Kendall's 65th birthday.

Probabilistic coupling refers to the practice of constructing two (or more) probability measures on a single measurable space in order to compare them. Some of its main applications include representing one process in terms of another, proving stochastic comparison arguments, bounding the rate of convergence of Markov processes, and simulation algorithms.

Some 45 people attended the workshop, which was funded by a London Mathematical Society Conference Grant, and co-sponsored by both the Bernoulli Society and the Royal Statistical Society. The program included talks by Prof. Krzysztof Burdzy (University of Washington) *Archimedes' principle for a ball in Knudsen gas*; Giacomo Zanella (Università Bocconi) *On the robustness of gradient-based sampling algorithms*; Prof. Huiling Le (University of Nottingham) *Stein's method for probability measures on manifolds*; Sayan Banerjee (University of North Carolina) *Non-parametric change point detection in growing networks*; Prof. Gareth Roberts (University of Warwick) *Coupling: from the past, into the future, and beyond*; Julia Brettschneider (University of Warwick)*Higher level spatial analysis of dead pixels on local grid geometry and applications to digital X-ray detector quality assessment*; Elisabetta Candellero (Università degli Studi Roma Tre) *Oil and water model on vertex transitive graphs*; and Prof. Jeffrey Rosenthal (University of Toronto) *Couplings for MCMC, adaptations, and mexit*.

There were seven additional shorter talks, all either delivered by Wilfrid's collaborators and colleagues, or concerning work inspired by his research. Topics covered include stochastic control, random growth models, optimal scaling of Metropolis-Hastings chains, phylogenetic tree analysis, the Restore Process, a new card shuffling model, and random walks with memory. The mixture of theory and applications, and the broad range of subjects covered, showed just how widely Wilfrid has influenced the field of probability during the last forty years. The workshop concluded with a very enjoyable conference dinner sponsored by the Department of Statistics at the University of Warwick. Further details about the workshop can be found at `https://tinyurl.com/wsk65`

Stephen Connor
Organizing Committee
York

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 BS Website `www.bernoulli-society.org/index.php/meetings`.

July 2020

- ◎July 6–10 (2020), *International Conference on Robust Statistics*; Wien, Austria (may be postponed).

August 2020

- ◎August 2–8 (2020), *XXIV Brazilian School of Probability*; Campinas, Brazil.

October 2020

- October 14–16 (2020), *3rd Spanish Young Statisticians and Operational Researchers Meeting*; Elche, Spain

January 2021

- ◎January 5–8 (2021), *Asia Pacific Rim Meeting*; Melbourne, Australia.

June 2021

- ◎June 14–18 (2021), *International Symposium on Nonparametric Statistics*; Paphos, Cyprus
- ◎June 28–July 01 (2021), *Rényi 100*; Budapest, Hungary.

July 2021

- ◎July 19–23 (2021), *Bernoulli-IMS World Congress*; Seul, Korea.

Postponed

- ◎*23rd Conference of the Romanian Society of Probability and Statistics*; Timisoara, Romania.
- ◎*Frontier Probability Days*; Las Vegas, USA.
- ◎*40th Finnish Summer School on Probability and Statistics*; Lammi, Finland.
- ◎*42nd Conference on Stochastic Processes and Applications*; Wuhan, China.

Quote of the Issue:

> "*I became passionate about human genetics because I saw it as one of the keys to a deeper understanding of human biology, leading in turn to improving medicine and healthcare.*"

Peter Donnelly

Recent Issues of Official Publications

Bernoulli

Vol. 26, No. 2: May 2020

Editors-in-Chief: M. Podolskij & M. Reiß

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

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Stochastic Processes and their Applications

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Editor-in-Chief: S. Méléard

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Bernoulli Society Bulletin e-Briefs

Vol. 39: February 2020

Editor-in-Chief: C. Améndola

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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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