# Stochastic Models V

Banach Center, Będlewo, Poland
September 11–17, 2016

Mathematical Institute,
University of Wrocław

Stefan Banach International
Mathematical Center

Warsaw Center of Mathematics
and Computer Science

## Organizing committee

Ryszard Szekli (head) Ryszard.Szekli@math.uni.wroc.pl
Bartłomiej Błaszczyszyn Bartek.Blaszczyszyn@ens.fr
Krzysztof Dębicki Krzysztof.Debicki@math.uni.wroc.pl
Paweł Lorek Pawel.Lorek@math.uni.wroc.pl
Zbigniew Palmowski Zbigniew.Palmowski@math.uni.wroc.pl

## Scientific committee

Prof. Søren Asmussen, Dep. of Math. Sciences, Aarhus University, Denmark
Prof. François Baccelli, INRIA, ENS Dép. d'Informatique, Paris, France
Prof. Onno Boxma, TU Eindhoven, Eurandom, The Netherlands
Prof. Daryl Daley, University of Melbourne, Australia
Prof. Sergey Foss, Heriot-Watt University, Great Britain
Prof. Günter Last, Karlsruhe Institute of Technology, Germany
Prof. Ryszard Szekli, University of Wrocław, Poland

## Secretary

Piotr Markowski Piotr.Markowski@math.uni.wroc.pl

## Technical assistance

Piotr Dyszewski Piotr.Dyszewski@math.uni.wroc.pl
Michał Krawiec Michal.Krawiec@math.uni.wroc.pl

# Contents

# 1 Abstracts

## Randomized Discrete Observations in Risk Theory

**Hansjoerg Albrecher,** *hansjoerg.albrecher@unil.ch*

This talk deals with the effects of discrete observation times on ruin probabilities and related quantities in an insurance context. It will be shown that for observations at independent Poisson epochs there are strikingly simple identities to the related quantities under continuous-time observation. This allows to rederive and extend a number of earlier results in the literature of collective insurance risk theory in a rather simple way. The talk is based on joint work with Jevgenijs Ivanovs.

# Load balancing in large graphs

**Venkat Anantharam,** *ananth@eecs.berkeley.edu*

We consider load balancing on a large graph. Each edge has a unit of load that it wishes to distribute between its nodes in the most balanced way. For infinite graphs the corresponding load balancing problem exhibits non-uniqueness, related to role of boundary conditions in statistical mechanical models. Nevertheless, we are able to extend the notion of balanced loads from large finite graphs to their local weak limits, using the concept of unimodularity. The result applies in particular to the Erdo"s-Renyi model, where it settles a conjecture of Hajek (1990). Our proof is a new illustration of the objective method described by Aldous and Steele (2004). All the necessary background from the machinery of local weak convergence that is needed will be developed during the talk. This machinery provides a way to study many problems of applied interest in large networks beyond just the load balancing problem that will be the focus of this talk. It is therefore valuable to familiarize oneself with this theory if one is interested in understanding the behavior of large networks such as wired and wireless networks, transportation networks, and social networks. (joint work with Justin Salez, Universit'e Paris Diderot)

# Left and Right Tail Behaviour of Lognormal Sums, with Applications to Insurance and Finance

**Soren Asmussen,** *asmus@imf.au.dk*

A standard model for the value $S = X_1 + \cdots + X_n$ of a portfolio of $n$ financial positions $X_1, \ldots, X_n$ is $X_i = e^{Y_1}$ where the vector $(Y_1 \ldots Y_n)$ is multivariate normal with possibly dependent components. Calculation of the right tail $P(S > x)$ is important in insurance because of the popularity of the lognormal as claim size distribution and in finance when the $X_i$ are losses or short positions, while the left tail $P(S \leq x)$ occurs when dealing with long positions. The calculations are non-trivial already for the i.i.d. case and I survey various approaches and recent asymptotic results. In particular these include Monte Carlo with variance reduction from either conditioning or importance sampling, saddlepoint approximations involving the Lambert W function and orthogonal polynomial expansions.

**Keywords**: Lambert W function; saddlepoint approximation; Monte Carlo

## References

[1] S. Asmussen & L. Rojas-Nandayapa (2008) Asymptotics of sums of lognormal random variables with Gaussian copula. *Statistics and Probability Letters.*

[2] S. Asmussen, J.L. Jensen & L. Rojas-Nandayapa (2014) On the Laplace transform of the lognormal distribution. *Methodology and Computing in Applied Probability*

[3] S. Asmussen, J.L. Jensen & L. Rojas-Nandayapa (2016) Exponential family techniques in the lognormal left tail. *Scandinavian Journal of Statistics*

[4] P. Laub, S. Asmussen, J.L. Jensen & L. Rojas-Nandayapa (2014) Approximating the Laplace transform of the sum of dependent lognormals. *Probability, Analysis and Number Theory* (Nick Bingham Festschrift). *Advances in Applied Probability* **48A**.

[5] S. Asmussen, P.-O. Goffard & P. Laub (2016) Orthonormal polynomial expansions and lognormal sum densities. *Risk and stochastics — Ragnar Norberg at 70.* World Scientific

# An invariance principle for sums and record times of stationary sequences

**Bojan Basrak,** *bbasrak@math.hr*

We consider weakly dependent stationary and regularly varying stochastic processes in discrete time and prove a sequence of results about their long term behavior. After describing the limiting distribution of individual clusters of extremes, we can show a new type of point process convergence theorem. Using it, we are able to prove a new functional limit theorem, which covers several time series models relevant in applications, for which standard limiting theory in the space $D$ of c'adl'ag functions fails. To describe the limit of partial sums in this more general setting we use the concept of so–called decorated c'adl'ag functions. We also apply our method to analyze asymptotics of record times in a stationary sequence. Under certain restrictions on dependence among the observations, we show that the record times after scaling converge to a relatively simple compound scale invariant Poisson process. The talk is based on the joint work with Hrvoje Planini'c and Philippe Soulier

# Optimal Dividend pay-out with Risk Sensitive Preferences

**Nicole Bauerle,** *nicole.bauerle@kit.edu*

We consider a discrete time dividend problem with risk sensitive preferences for the dividends. This leads to a non-expected recursive utility of the dividends which is constructed with the help of the exponential premium principle. Models like this have the advantage that the variability of the dividends is also taken into account and risk aversion can be introduced. This kind of research has been motivated in a remark in Gerber and Shiu (2004). We develop the theoretical tools in order to solve these kind of optimization problems for finite and infinite time horizons. Moreover we prove that even in this general setting, the optimal dividend policy is a band policy. We also showthat the policy improvement algorithm can be used to compute the optimal policy and the corresponding value function. An explicit example is given where we can show that a barrier policy is optimal. Finally some surprising numerical examples are provided where we discuss the influence of the risk sensitive parameter on the optimal dividend policy. The talk is based on joint works with A. Jaśkiewicz.

# Gerber–Shiu distribution at Parisian ruin for Lévy insurance risk processes

**Erik Baurdoux,** *e.j.baurdoux@lse.ac.uk*

Inspired by works of Landriault et al. (2011, 2014) we study the Gerber–Shiu distribution at Parisian ruin with exponential implementation delays for a spectrally negative Lévy Lévy insurance risk process. To be more specific, we study the so-called Gerber–Shiu distribution for a ruin model where at each time the surplus process goes negative, an independent exponential clock is started. If the clock rings before the surplus becomes positive again then the insurance company is ruined. Our methodology uses excursion theory for spectrally negative Lévy processes and relies on the theory of so-called scale functions. This talk is based on joint work with Juan Carlos Pardo, Jos'e Luis P'erez and Jean-Franccois Renaud.

**References:**

[1] Baurdoux, E. J. , Pardo, J.C., Perez, J.L. and Renaud, J. F. (2016) Gerber—Shiu distribution at Parisian ruin for Lévy insurance risk processes it J. Appl. Probab. f 53 (2), 572–584.

[2] Landriault, D., Renaud, J.-F. and Zhou, X. (2011). Occupation times of spectrally negative Lévy processes with applications. it Stochastic Process. Appl. f 121, 2629–2641.

[3] Landriault, D., Renaud, J.-F. and Zhou, X. (2014). An insurance risk models with Parisian implementation delays. it Methodol. Comput. Appl. Probab. f 16 (3), 583–607.

# Branching Random Walk, Regular Variation and Stable Point Processes: Branching Process in Random Environment

**Ayan Bhattacharya,** *ayanbhattacharya.isi@gmail.com*

We consider the model branching random walk in random environment with regularly varying displacements. We shall obtain the weak limit of the sequence of point processes associated to it. This is an ongoing joint work with Zbigniew Palmowski.

# Queue-length balance equations in multiclass multiserver queues

**Onno Boxma,** *o.j.boxma@tue.nl*

A classical result for the steady-state queue-length distribution of single-class queueing systems is the following: the distribution of the queue length just before an arrival epoch equals the distribution of the queue length just after a departure epoch. The constraint for this result to be valid is that arrivals, and also service completions, with probability one occur individually, i.e., not in batches. We show that it is easy to write down somewhat similar balance equations for multidimensional queue-length processes for a large family of multiclass multiserver queues with Poisson arrivals – even when arrivals may occur in batches. We demonstrate the use of these balance equations, in combination with PASTA, by (i) providing very simple derivations of some known results for polling systems, and (ii) obtaining new results for some queueing systems with priorities. Note: this is joint work with Marko Boon, Offer Kella and Masakiyo Miyazawa.

# Ruin probabilities in a discrete insurance risk process with Pareto claims

**Corina Constantinescu,** *c.constantinescu@liv.ac.uk*

We present basic properties and potential insurance applications of a recently introduced class of probability distributions on positive integers with power law tails, which are discrete counterparts of the Pareto distribution. In particular, we obtain a probability of ruin in the compound binomial risk model where the claims are zero-modified discrete Pareto distributed and correlated by mixture. This is join work with Tomasz J. Kozubowski

# Parisian ruin for a refracted Lévy process

**Irmina Czarna,** *czarna@math.uni.wroc.pl*

We investigate Parisian ruin for a Lévy surplus process with an adaptive premium rate, namely a refracted Lévy process. More general Parisian boundary-crossing problems with a deterministic implementation delay are also considered. Our main contribution is a generalization of the result in [1] for the probability of Parisian ruin of a standard Lévy insurance risk process. Despite the more general setup considered here, our main result is as compact and has a similar structure. Examples are provided.

**References:**

[1] R. Loeffen, I. Czarna, Z. Palmowski, Parisian ruin probability for spectrally negative Lévy processes, Bernoulli 2013, Vol. 19, No. 2, 599-609.

[2] M.A. Lkabous, I. Czarna, J.-F. Renaud, Parisian ruin for a refracted Lévy process, draft

# Alternating birth-death processes in a random environment

**Hans Daduna,** *daduna@math.uni-hamburg.de*

We consider a continuous time Markov process on $\mathbb{N}_0$ which can be considered as birth-death process in a random environment. Depending on the status of the environment the process either increases until the environment changes and the process starts to decrease until the environment changes again, and the process restarts to increase, and so on, or its starts decreasing, reversing its direction due to environmental changes, et cetera. We allow the birth and death rates to depend on the state (height) of the birth-death process and the environment transition rates to depend on the state (height) of the birth-death process as well. We furthermore allow that an immediate change of the environment status is triggered by an arrival or departure. When removing the boundary at zero we obtain a two-sided version of this birth-death process, which for suitable parameter constellations is ergodic as well. We determine the stationary distribution. This two-sided version is a discrete version of the telegraph process. Our main result is in both cases an explicit expression for the stationary distribution if the system is ergodic, providing ergodicity conditions as well. We show that these processes represent a versatile class of models. Some examples from the literature will be discussed.

# Renewal function asymptotics refined a la Feller

**Daryl Daley,** *dndaley@gmail.com*

Feller's Volume 2 (1966) exploits the key renewal theorem to show that the renewal function $U$ of a renewal process whose generic lifetime random variable $X$ has a nonlattice distribution with mean $1/\lambda$ and finite second moment, has the asymptotic behaviour

$$(*) \qquad U(x) - \lambda x \to E[(\lambda X)^2]/2$$

as $x \to \infty$. Feller then remarks that "[this] asymptotic expansion of $U$ may be further refined if $X$ has moments of higher order", and "this method [of using the general renewal equation to establish (*)] can be used for better estimates when higher moments exist." Feller's later edition (1971) omits both these remarks whose meaning I shall try and elucidate.

## Perpetuities with super-heavy tails

**Piotr Dyszewski,** *pdysz@math.uni.wroc.pl*

Consider a sequence of independent identically distributed two–dimensional random vectors $(A_n, B_n)_{n\in\mathbb{N}}$. Using this sequence we can define a Markov chain via the random difference equation

$$R_{n+1} = A_{n+1}R_n + B_{n+1} \qquad \text{for } n \geq 0,$$

where $R_0$ is arbitrary but independent of the sequence $(A_n, B_n)_{n\in\mathbb{N}}$. It is a well known fact that if $\mathbb{E}[\log|A_1|] < 0$ and $\mathbb{E}[\log^+|B_1|] < \infty$ the Markov chain $R_{n n\in\mathbb{N}}$ has a unique stationary distribution which can be represented as the distribution of the random variable

$$R = \sum_{n\geq 0} B_{n+1} \prod_{k=1}^{n} A_k.$$

Assuming that the integrated tail function of $\log(|A_1| \vee |B_1|)$ is subexponential, we will investigate the asymptotic of $\mathbb{P}[R > x]$ as $x \to \infty$.

# A local limit theorem for QuickSort key comparisons via multi-round smoothing

**James Allen Fill,** *jimfill@jhu.edu*

It is a well-known result, due independently to Régnier (1989) and Rösler (1991), that the number of key comparisons required by the randomized sorting algorithm QuickSort to sort a list of $n$ distinct items (keys) satisfies a global distributional limit theorem. We resolve an open problem of Fill and Janson from 2002 by using a multi-round smoothing technique to establish the corresponding local limit theorem. This is joint work with Béla Bollobás and Oliver Riordan.

# Optimal control of a stochastic model related to an energy system with renewables

**Sergey Foss,** *s.foss@hw.ac.uk*

I will introduce a new model with two generators of energy, conventional and renewable. The conventional generator has ramp constraints while the renewable one is unreliable. I will discuss problems of optimising the level of excess energy to minimise the system financial loss. The talk is based on a joint work with Ksenia Chernysh and Stan Zachary.

# Generalised Pickands and Piterbarg constants

**Enkelejd Hashorva,** *enkelejd.hashorva@unil.ch*

The classical Pickands and Piterbarg constants appear in various problems related to extremes of Gaussian processes and random fields, such as exact tail asymptotics of Gumbel limit laws. In this talk we shall discuss various generalisations of those constants which relate to max-stable random fields. Our main results concern new formulas, upper and lower bounds, and examples where these constants appear. Joint work with Krzyś Debicki

# Asymptotic theory for the sample autocovariance matrix of a high-dimensional heavy-tailed linear time series

**Johannes Heiny,** *johannes.heiny@math.ku.dk*

Many fields of modern sciences are faced with high-dimensional data sets. In order to explore the structure in the data the sample covariance matrix can be used. Often dimension reduction techniques facilitate further analyzes of large data matrices in genetic engineering and finance. Principal Component Analysis for example makes a linear transformation of the data to obtain vectors of which the first few contain most of the variation in the data. These principal component vectors correspond to the largest eigenvalues of the sample covariance matrix. This motivates to study the eigenvalue decomposition of the sample covariance matrix. Random Matrix Theory is concerned with the spectral properties of large dimensional random matrices. In this context both the distribution of the entries of a random matrix as well as their dependence structure play a crucial role. The case of heavy-tailed components is of particular interest and the theory is not as well developed as in the light-tailed case. We consider asymptotic properties of sample covariance matrices for heavy-tailed time series, where both the dimension and the sample size tend to infinity simultaneously. We derive the limiting point process of eigenvalues of such matrices via large deviation and extreme value theory techniques. As a consequence, we obtain the asymptotic distribution of the largest eigenvalues.

# Robust bounds in multivariate extremes

**Jevgenij Ivanovs,** *jevgenijs.ivanovs@unil.ch*

Extreme value theory provides an asymptotically justified framework for estimation of exceedance probabilities in regions where few or no observations are available. In multivariate setup, the strength of extremal dependence is crucial for a reliable estimation and it is typically modelled by a parametric family of (spectral) distributions. In this work we provide asymptotic bounds on exceedance probabilities that are robust against misspecification of the extremal dependence model. They are found by optimizing the statistic of interest over all dependence models within some neighbourhood of the reference model. Certain relaxation of these bounds results in surprisingly simple and explicit expressions, which we propose to use in applications. Our experiments show the effectiveness of the proposed bounds compared to classical confidence bounds when the model is misspecified. This is a joint work with Sebastian Engelke.

# First order Kendall maximal autoregressive processes

**Barbara Jasiulis Gołdyn,** *barbara.jasiulis@math.uni.wroc.pl*

We consider the following extremal Markovian sequence:

$$S_0 = 0,\ S_1 = X_1,\ \ S_n = max(S_{n-1}, X_{n-1})\theta_{n-1}^{Q_{n-1}} a.e.,$$

where $\{X_i\}$ is the unit step of random walk and i.i.d., $\{\theta_i\}$ is i.i.d. with the Pareto distribution such that $\theta_i$ is independent of $S_i$ and $X_i$, $\{Q_i\}$ is a sequence such that $Q_i$ depends on $S_i$ and $X_i$. The stochastic process is the Lévy process in generalized convolution sense ([4]). Structure of considered processes is similar to the first order autoregressive maximal Pareto processes ([2], [3], [11]), the max-autoregressive moving average processes MARMA ([6]), minification process ([10], [11]), extremal Markovian sequences ([1]) or perpetuity. Our construction is based on the Kendall convolution defined by:

$$\delta_x \vartriangle_\alpha \delta_1 = x^\alpha \pi_{2\alpha} + (1 - x^\alpha)\delta_1, \quad x \in [0, 1],$$

where $\pi_{2\alpha}$ is the Pareto measure with the density function $\pi_{2\alpha}(x) = 2\alpha x^{-2\alpha-1}\mathbf{1}_{[1,\infty)}(x)$. One can prove that the Kendall convolution produces new classes of heavy tailed distributions [5]).

We prove some properties of hitting times and an analogue of the Wiener-Hopf factorization for the Kendall random walk ([7], [8], [9]). We show also that the Williamson transform ([14]) is the best tool for problems connected with the Kendall generalized convolution.

**References:**

[1] **T. Alpuim**, *An Extremal Markovian Sequence*, *J. Appl. Math.*, **26**(2), 219–232, 1989.

[2] **B. C. Arnold**, *Pareto Processes*, *Stochastic Processes: Theory and Methods. Handbook of Statistics*, **19**, 1–33, 2001.

[3] **B. C. Arnold**, *Pareto Distributions*, *Monographs on Statistics and Applied Probability*, **140**, Taylor & Francis Group, 2015.

[4] **M. Borowiecka-Olszewska, B.H. Jasiulis-Gołdyn, J.K. Misiewicz, J. Rosiński**, *Weak Lévy processes and weak stochastic integral*, *Bernoulli*, **21**(4), 2513–2551, 2015, arXiv: http://arxiv.org/pdf/1312.4083.pdf.

[5] **P. Embrechts, K. Kluppelberg, T. Mikosch**, *Modelling Extremal Events: For Insurance and Finance*, *Applications of Mathematics, Stochastic Modelling and Applied Probability* **33**, Springer-Verlag Berlin Heidelberg, 1997.

[6] **M. Ferreira**, *On the extremal behavior of a Pareto process: an alternative for ARMAX modeling*, *Kybernetika* **48**(1), 31–49, 2012.

[7] **B.H. Jasiulis-Gołdyn**, *Kendall random walks*, in press: *Probab. Math. Stat.*, **36**(1), 165-185, 2016, arXiv: http://arxiv.org/pdf/1412.0220v1.pdf.

[8] **B.H. Jasiulis-Gołdyn, J.K. Misiewicz**, *Classical definitions of the Poisson process do not coincide in the case of weak generalized convolution*, *Lith. Math. J.*, **55**(4), 518-542, 2015, arXiv: http://arxiv.org/pdf/1312.6943.pdf.

[9] **B.H. Jasiulis-Gołdyn, J.K. Misiewicz**, *Kendall random walk, Williamson transform and the corresponding Wiener-Hopf factorization*, in press: *Lith. Math. J.*, 2016, arXiv: http://arxiv.org/pdf/1501.05873.pdf.

[10] **P.A.W. Lewis, Ed McKenzie**, *Minification Processes and Their Transformations*, *Journal of Applied Probability*, **28**(1), 45–57, 1991.

[11] **J. Lopez-Diaz, M. Angeles Gil, P. Grzegorzewski, O. Hryniewicz, J. Lawry**, *Soft Methodolody and Random Information Systems*, Advances in Inteligent and Soft computing, Springer, 2004.

[12] **A.J. McNeil, J. Nešlehová**, *Multivariate Archimedean Copulas, $d-$ monotone Functions and $l_1-$ norm Symmetric Distributions*, *Ann. Statist.*, **37**(5B), 3059–3097, 2009.

[13] **V. Vol'kovich, D. Toledano-Ketai, R. Avros**, *On analytical properties of generalized convolutions*, *Banach Center Publications, Stability in Probability*, **5**(3), 243–274, 2010.

[14] **R. E. Williamson**, *Multiply monotone functions and their Laplace transforms*, *Duke Math. J.* **23**, 189—207, 1956.

# Parisian Ruin & Parisian Ruin Times of Gaussian Risk Models

**Lanpeng Ji,** *jilanpeng@126.com*

In this talk, I am going to present some recent results on Parisian ruin of Gaussian risk models. Precisely, for a risk process $R(t) = u + ct - X(t)$, where $u \geq 0$ is the initial capital, $c > 0$ is the premium rate and $X(t)$ is an aggregate claim process which is modelled by a general Gaussian process, we derive asymptotics of the finite and infinite time Parisian ruin probabilities. Approximation of the conditional Parisian ruin time given that ruin happens will also be discussed.

# Cramer-Lundberg risk model with asymptotically zero drift

**Dmitri Korshunov,** *d.korshunov@lancaster.ac.uk*

We discuss approximations for ruin probabilities in Cramer-Lundberg risk model in the case where premium rate depends on current surplus process in such a way that the drift in the system is asymptotically zero but the ruin probability is still less than 1.

## Stability of linear EDF networks with resource sharing

**Łukasz Kruk,** *lkruk@hektor.umcs.lublin.pl*

We consider a linear real-time, multi-resource network with generally distributed stochastic primitives and soft customer deadlines, in which some users require service from several shared resources simultaneously. We show that a strictly subcritical network of this type is stable under the preemptive Earliest Deadline First (EDF) scheduling strategy. Our argument is direct, without using fluid model analysis as an intermediate step.

# On the Poisson driven random connection model

**Guenter Last,** *guenter.last@kit.edu*

We consider a Poisson process on a general phase space. The random connection model (RCM) is a random (undirected) graph whose vertices are given by the Poisson points and whose edges are obtained by connecting pairs of Poisson points at random. The connection decisions are allowed to depend on the positions of the two involved vertices but are otherwise independent for different pairs and independent of the other Poisson points. The focus of the talk will be on the finite clusters of the RCM. We shall discuss first and second order properties of the point processes counting the clusters isomorphic to a given graph. In the second part of the talk we specialize to an Euclidean phase space with an isotropic connection function. In this case we can derive a multivariate central limit theorem for the number of clusters in a growing observation window. The proof is based on some new (and presumably optimal) Berry-Esseen bounds for the normal approximation of functionals of a pairwise marked Poisson process. This talk is based on joint work with Franz Nestmann (Karlsruhe) and Matthias Schulte (Bern).

## Extremes of transient Gaussain fluid queues

**Peng Liu,** *liupnankaimath@163.com*

In this talk, we consider the transient queue described by

$$Q_x(t) = \max\left(x + X(t) - ct, \sup_{0\le s\le t}\left(X(t) - X(s) - c(t-s)\right)\right), t \ge 0,$$

where $x > 0$ and $X$ is a Gaussian process with stationary increments. We derive the asymptotic tail of the workload distribution at time $T_u$

$$\mathbb{P}\left(Q_x(T_u) > u\right)$$

and the overload probability over a threshold-dependent interval $[0, T_u]$, i.e.,

$$\mathbb{P}\left(\sup_{t\in[0,T_u]} Q_x(t) > u\right),$$

as $u \to \infty$ under some mild conditions for $X$ and $T_u$. As a by-product of the obtained results, we discuss some issues related with the speed to stationarity of the queueing system in time.

# On a class of time inhomogeneous affine processes

**Ronnie Loeffen,** *ronnie.loeffen@manchester.ac.uk*

One-dimensional, positive, affine processes are well-studied and have been applied to e.g. interest rate, credit risk and stochastic mortality modelling. Here we consider a slightly more general class by including a time inhomogeneity component. We present a new technique for computing the Laplace transform which has some advantages over the standard method consisting of computing the generalised Riccati equations. We also show why the class is richer than the time homogeneous one by looking at shapes of yield curves in short rate models.

# Siegmund duality and Möbius monotonicity with applications to Generalized Gambler's Ruin Problem

**Paweł Lorek,** *Pawel.Lorek@math.uni.wroc.pl*

We will present some Generalized Gambler's Ruin Problem and will give explicite formulas for ruin/winning probabilities. The generalization is two-folded: 1) winning/losing probabilities depend on current capital; 2) it is multidimensional game, which can be interpreted as a game of one player vs $d \geq 1$ players. It contains many previous generalizations as special cases.

Solving some recurrence relations is the classical approach to solving ruin-like problems. We will present different approach. We will show main result of [2]: For Markov chains on finite partially ordered state space we show that Siegmund dual exists if and only if the chain is Möbius monotone (monotonicity applied initially to Strong Stationary Duality, see [3,4]), in which case we give formula for its transitions. Exploiting the relation between ergodic Markov chain and its Siegmund dual we give a procedure for solving ruin-like problems. We will apply the results to the aforementioned Generalized Gambler's Ruin Problem (presented in details in [1]). Relations between Möbius and other monotonicities will also be shortly presented.

**References:**


[1] **Lorek, P.** Generalized Gambler's ruin problem: explicit formulas via duality. *Methodology and Computing in Applied Probability* (Open Access), 2016.

[2] **Lorek, P.** Siegmund duality for Markov chains on partially ordered state spaces. (submitted), 2016.

[3] **Lorek, P., Szekli R.** Strong stationary duality for Mobius monotone Markov chains. *Queueing Systems* 71, 79–95, 2012.

[4] **Lorek, P., Szekli R.** Strong stationary duality for Mobius monotone Markov chains: examples. *Probability and Mathematical Statistics* 36(1), 75–07, 2016.

# Erlang-B and Erlang-A models in a modulated environment.

**Michel Mandjes,** *m.r.h.mandjes@uva.nl*

The first part of this work focuses on a loss system in which both the arrival rate and the per-customer service rate vary according to the state of an underlying finite-state, continuous-time Markov chain. Our first contribution consists of a closed-form expression for the stationary distribution of this Markov-modulated Erlang loss queue. Furthermore, we consider a regime where, in a way that is common for this type of loss system, we scale the arrival rate and the number of servers, while also scaling the transition rates of the modulating Markov process. We establish convergence of the stationary distribution to a truncated Normal distribution, which leads to an approximation for the blocking probability. In this regime the parameters of the limiting distribution critically depend on the precise scaling imposed. Numerical experiments show that the resulting approximations are highly-accurate. In the second part of the talk I consider the Erlang-A model in which there is the option of waiting (if all servers are busy) and abandonments. Work with Marijn Jansen, Koen de Turck and Peter Taylor.

# Monotonicity requirements for exact sampling with Markov chains.

**Piotr Markowski,** *pir2o61@gmail.com*

Coupling From The Past (CFTP [5]) is the algorithm for so-called perfect sampling, i.e., it returns unbiased sample from the stationary distribution of a Markov chain. To apply it effectively the chain must be monotone in some specific way, namely realizable monotonicity of the chain is required. This monotonicity is defined with respect to some partial ordering of the state space. For total ordering it is equivalent to stochastic monotonicity, but in general these are two different notions of monotonicity.

We recall two another methods for perfect sampling: method based on Strong Stationary Duality (SSD [1],[4]) and Fill's rejection algorithm ([2]). To apply these algorithms effectively also some monotonicity is required. SSD-based algorithm requires Möbius monotonicity, whereas Fill's rejection algorithm requires stochastic monotonicity.

We present results from ([3]) showing relations between monotonicities and connections to aforementioned perfect sampling algorithms. In particular we show *i*) the chain can be Möbius but not stochastically nor realizably monotone (which means that CFTP and Fill's rejection algorithms are not applicable, whereas SSD-based one is); *ii*) realizable monotonicity implies stochastic monotonicity but do not imply Möbius monotonicity (which means that applicability of CFTP algorithm implies applicability of Fill's rejection algorithm but do not imply applicability of SSD-based algorithm).

**References:**

[1] Diaconis, P., Fill, J. A. (1990). Strong stationary times via a new form of duality. The Annals of Probability, 18(4), 1483–1522

[2] Fill, J. A. (1998). An interruptible algorithm for perfect sampling via Markov chains. The Annals of Applied Probability, 8(1), 131–162

[3] Lorek, P., Markowski, P. (2016). Monotonicity requirements for exact sampling with Markov chains. (submitted to Markov Processes and Related Fields)

[4] Lorek, P., Szekli, R. (2012). Strong stationary duality for Möbius monotone Markov chains. Queueing Systems, 71(1-2), 79–95.

[5] Propp, J. G., Wilson, D. B. (1996). Exact sampling with coupled Markov chains and applications to statistical mechanics. Random Structures & Algorithms, 9, 223–2526

## The eigenstructure of the sample covariance matrix of a regularly varying multivariate time series

**Thomas Mikosch,** *mikosch@math.ku.dk*

This is joint work with Richard A. Davis (Columbia Statistics), Johannes Heiny and Xiaolei Xie (Copenhagen). We consider a $p$-dimensional time series whose dimension increases with the sample size $n$. We assume that the rows of this series constitute a stationary sequence and that there is dependence between the rows. We also assume heavy tails in the sense that the finite-dimensional distributions of the time series are regularly varying with infinite 4th moment. Work by Soshnikov, Auffinger, Ben Arous and P'ech'e in the iid case shows that the largest eigenvalues are approximated by the points of a suitable non-homogeneous Poisson process. We follow this line of research. We study the eigenvalues and eigenvectors of the sample covariance matrix of linear processes and stochastic volatility models. In these models, the sums of squares of regularly varying random variables dominate the eigenvalues of the sample covariance matrix as well as their eigenvectors. These sums of squares also determine the limiting point process of the scaled eigenvalues which turns out to be a Poisson cluster process.

# Martingale approach for tail asymptotic problems in the generalized Jackson network

**Masakiyo Miyazawa,** *miyazawa@is.noda.tus.ac.jp*

We study the tail asymptotic of the stationary joint queue length distribution for a generalized Jackson network, assuming its stability. There are two types of asymptotics, called logarithmic and exact. For the two node case, this problem has been recently solved for the logarithmic asymptotics under the setting that inter-arrival and service times have phase-type distributions. In this paper, we generalize them in two ways. First, we allow those distributions to be general in the two node case. Second, we derive some bounds for the tail decay rates in the case more than two node. Our approach is based on a martingale for a piecewise deterministic Markov process, and change of measure using it.

# On the tail asymptotics of signal-to-interference ratio distribution in downlink cellular networks

**Naoto Miyoshi,** *miyoshi@is.titech.ac.jp*

We consider the spatial stochastic model of single-tier downlink cellular networks, where the wireless base stations are deployed according to a general stationary point process on the Euclidean space with general i.i.d. propagation effects. Recently, Ganti & Haenggi (2016) consider the similar general cellular network model and obtain the tail asymptotics of the signal-to-interference ratio (SIR) distribution. However, they do not mention any conditions under which the asymptotic result is validly derived. In this work, we complement their result with a sufficient condition for the asymptotic result to be derived. We further illustrate some examples satisfying the sufficient condition and indicate the corresponding asymptotic results. We also give a simple counterexample violating the sufficient condition. This is a joint work with Tomoyuki Shirai.

**References:**

[1] R. K. Ganti & M. Haenggi (2016). Asymptotics and approximation of the SIR distribution in general cellular networks, IEEE Trans. Wireless Commun., vol. 15, 2130–2143.

[2] N. Miyoshi & T. Shirai (2016). A sufficient condition for tail asymptotics of SIR distribution in downlink cellular networks, WiOpt 2016, 454–460.

## Convex hulls of Levy processes

**Ilya Molchanov**, *ilya.molchanov@stat.unibe.ch*

The talk presents several results related to properties of the convex hull of Levy processes. It is shown that all intrinsic volumes of the convex hull are integrable and their expectations explicitly found in the stable case. A limit theorem for normalised convex hulls is also obtained.

# Asymptotic properties of random quantum states and channels

**Zbigniew Puchała,** *z.puchala@iitis.pl*

Properties of random mixed states and quantum channels distributed uniformly with respect to the Hilbert-Schmidt measure are investigated. We show that for large $N$, due to the concentration of measure, the trace distance between two random states tends to a fixed number $\tilde{D} = 1/4 + 1/\pi$, which yields the Helstrom bound on their distinguishability. We also show, that completely bounded trace norm, i.e. the diamond norm, for two random quantum channels tends to the same number number $\tilde{D}$. To arrive at this result we apply free random calculus and derive the symmetrized Marchenko–Pastur distribution. Asymptotic values for the fidelity, Bures and transmission distances between two random states are obtained. Analogous results for quantum relative entropy and Chernoff quantity provide other bounds on the distinguishablity of both states in a multiple measurement setup due to the quantum Sanov theorem.

# Contact distribution in a thinned Boolean model with power law radii

**Gennady Samorodnitsky,** *gs18@cornell.edu*

We consider a weighted stationary spherical Boolean model in $R^d$. Assuming that the radii of the balls in the Boolean model have regularly varying tails, we establish the asymptotic behaviour of the tail of the contact distribution of the thinned germ-grain model under 4 different thinning procedures of the original model.

# Drawdown and drawup exit problems for a spectrally negative Lévy process with applications in pricing insurance contracts

**Joanna Tumilewicz,** *joanna.tumilewicz@gmail.com*

Let $X_t$ be a spectrally negative Lévy process. We define drawdown/drawup of the process $X_t$ by

$$D_t = \overline{X}_t \vee y - X_t, \qquad U_t = X_t - \underline{X}_t \wedge (-z),$$

where $\overline{X}_t = \sup_{0\leq s\leq t} X_s$ and $\underline{X}_t = \inf_{0\leq s\leq t} X_s$.

We consider the following first-passage times:

$$\begin{aligned} \tau_D^+(a) &= \inf\{t \geq 0 : D_t \geq a\}, & \tau_U^+(b) &= \inf\{t \geq 0 : U_t \geq b\}, \\ \tau_D^-(a) &= \inf\{t \geq 0 : D_t \leq a\}, & \tau_U^-(b) &= \inf\{t \geq 0 : U_t \leq b\}. \end{aligned} \tag{1}$$

Our main goal is to identify the price of the following insurance contracts:

$$F(y,p) = \sup_{\tau\in\mathcal{T}} \mathbb{E}\left[-\int_0^{\tau_D^+(a)\wedge\tau} e^{-rt}p dt - ce^{-r\tau}\mathbf{1}_{\{\tau<\tau_D^+(a)\}} + \alpha e^{-r\tau_D^+(a)}\mathbf{1}_{\{\tau_D^+(a)\leq\tau\}} | D_0 = y\right]$$

and

$$\begin{aligned} K(y,z,p) = \sup_{\tau\in\mathcal{T}} \mathbb{E}\Bigg[ &-\int_0^{\tau_D^+(a)\wedge\tau_U^+(b)\wedge\tau} e^{-rt}p dt + \alpha e^{-r\tau_D^+(a)}\mathbf{1}_{\left\{\tau_D^+(a)<\tau_U^+(b)\wedge\tau\right\}} \\ &- ce^{-r\tau}\mathbf{1}_{\left\{\tau<\tau_D^+(a)\wedge\tau_U^+(b)\right\}} | D_0 = y,\ U_0 = z \Bigg], \end{aligned}$$

where all parameters are non-negative and correspond to: $p$ - premium level, $r$ - free interest rate, $\alpha$ - reward, $c$ - fee for terminating contract, $a$ and $b$ - levels of drawdown and drawup of process $X_t$, respectively. $\mathcal{T}$ denotes the family of stopping times considered with respect to the natural filtration of $X$ satisfying usual conditions.

The proofs of the main results are based on so-called Verification Theorem and on the identification of the following functionals:

$$\begin{aligned} \xi(y) &= \mathbb{E}\left[e^{-r\tau_D^+(a)} | D_0 = y\right], \\ \nu(y,z) &= \mathbb{E}\left[e^{-r\tau_D^+(a)}; \tau_D^+(a) \leq \tau_U^+(b) | D_0 = y, U_0 = z\right], \\ \lambda(y,z) &= \mathbb{E}\left[e^{-r\tau_U^+(b)}; \tau_U^+(b) < \tau_D^+(a) | D_0 = y, U_0 = z\right]. \end{aligned}$$

Talk is based on join work with Z. Palmowski [1] and the paper of Mijatovic and Pistorius [2].

# References

[1] Palmowski, Z. and Tumilewicz, J. (2016). Fair valuation of drawdown polices derived by a spectrally negative Lévy processes. *Submitted for publication.*

[2] Mijatović, A. and Pistorius, M.R. (2012) On the drawdown of completely asymmetric Lévy process. *Stochastic Processes and their Applications*, **122(11)**, 3812–3836.

# Asymptotic error bounds for truncated buffer approximations of a 2-node tandem queue

**Maria Vlasiou,** *m.vlasiou@tue.nl*

We consider the queue lengths of a tandem queuing network. The number of customers in the system can be modelled as QBD with a doubly-infinite state-space. Due to the infinite phase-space, this system does not have a product-form solution. A natural approach to find a numerical solution with the aid of matrix analytic methods is by truncating the phase-space; however, this approach imposes approximation errors. We study these approximation errors mathematically, using large deviations and extreme value theory. We obtain a simple asymptotic error bound for the approximations that depends on the truncation level. We test the accuracy of our bound numerically.

# Biased Random Walks on $\mathbb{Z}^d$

**Longmin Wang**, *longminwang@gmail.com*

Let $G = (V, E)$ be a locally finite, connected infinite graph and fix a vertex $o \in V$ as the root. For $\lambda \in (0, infty)$, define the conductance $c_\lambda$ on $E$ by $c_\lambda(e) = \lambda^{-|e|}$, where $|e|$ is the graph distance from $o$. Denote by $\mathrm{RW}_\lambda$ the random walk associated to the network $(G, c_\lambda)$. In this talk, we will consider some basic properties, such as spectral radius, escape rate and heat kernel, of $\mathrm{RW}_\lambda$ on $\mathbb{Z}^d$. As an application, we will consider the number of trees in the uniform spanning forest related to $\mathrm{RW}_\lambda$ on $\mathbb{Z}^d$.

## Random $d$-Complexes : Persistence diagram and spanning acycles.

**Dhandapani Yogeshwaran,** *d.yogesh@gmail.com*

It is well-known that extremal edge-weights on a minimal spanning tree, nearest-neighbour distances and connectivity are inter-related for randomly weighted graphs. In this talk, we shall look at generalization of this result to random simplicial complexes. The first part of the talk shall be concerned with establishing some basic properties of spanning acycles and thereby justifying it as a natural topological generalisation of spanning trees. Further, we shall extend the Kruskal's algorithm and Prim's algorithm to simplicial complexes and thereby, providing algorithms for generating minimal spanning acycles. As a consequence of the simplicial Kruskal's algorithm, we shall obtain a connection between minimal spanning acycles and persistent diagrams. In the second part, we shall explore applications of these results in the context of random $d$-complexes and in particular, paying attention to extremal face-weights of the minimal spanning acycles on a complete d-complex with i.i.d. face weights. We shall relate them to extremal weights on a natural nearest-neighbour hypergraph as well as higher-dimensional connectivity of the random $d$-complex. We shall finally discuss stability results in this context and thereby extending our results to certain class of dependent perturbations of i.i.d. face-weights. This is a joint work with Primoz Skraba and Gugan Thoppe.

# Preventing the lights go out: stochastic models of power systems with uncertain supply and demand

**Bert Zwart,** *bert.zwart@cwi.nl*

An increased demand for electricity, the emergence of new technologies, the need to incorporate renewables,and the transformation of electricity markets are only a few reasons why energy networks deserve our attention. In this talk, I focus on mathematical models that are inspired by reliability issues in electricity networks. I will first show an application of Ventsell-Freidlin theory to determine capacity regions which can help a safe operation of power grids. After that, motivated by the desire to understand the nature of large blackouts, I will consider a model of cascading failure dynamics.

## 2 Memories about Tomasz Rolski

# Three Meetings with Tomasz Rolski

*Dietrich Stoyan*

## The Early Time

Tomasz Rolski is my eldest foreign friend. In this short text I will describe three personal meetings with him, which may reveal some aspects of his personality.

It is not by chance that just a Polish mathematician was the first foreigner with whom I had closer scientific contacts. In the early 1970ies I wrote a series of papers on the comparison of queues and looked for journals outside of the German Democratic Republic (which started around that time its decline). Since Western journals were unthinkalble, I quite naturally decided to choose Czechoslovak and Polish journals. I was successful in both cases though I still wrote in German at that time. My paper to *Zastosowania Matematyki*, today *Applicationes Math. (Warsaw)* (see Stoyan, 1972) submitted in September 1971 was particularly thoroughly worked through in the editorial office by a young colleague, Tomasz Rolski, who worked in Wrocław under professor Jozef Łukaszewicz. On November 27, 1971, I sent him a personal letter, in German (did he really understand it fully?), to the good old address *Plac Grunwaldzki 4/2.* I wrote "...cordially thank you for your work with my paper and for kindly detecting some errors." Furthermore, I commented a paper he sent me, Rolski (1972) on the comparison of GI/M/$n$ queues and expressed my pleasure that "also other researchers work in the same direction as me." I concluded with "Perhaps we could make joint work in future."

Then in Spring 1972, Tomasz came to Freiberg, back then still an adventure, of course by train. I waited for him at the railway station. He was a small, thin guy with black hairs and a pointed nose; I already had a bald head; his English was better than mine. We had efficient personal discussions in our small flat, I lived with my wife Helga and two young children in a two-room flat. (In communist countries there was always housing-shortage.)

This finally led to a joint paper "Some quasi-orderings relations for random variables and their application in the theory of queues" by Tomasz and myself. We tried to offer the orders $\leq_{s-icx}$ and $\leq_{s-icv}$ (in the notation of Müller and Stoyan, 2002) for general use. In that time we both still did not quite know the style of international journals such as Journal of Applied Probability. And of course, the relations $\leq_{s-icx}$ and $\leq_{s-icv}$ are not so attractive as the convex and concave orders $\leq_{cx}$ and $\leq_{cv}$. Thus our paper was rejected. If we, Tomasz and I, would be today referees of a similar paper we would clearly reject it too. Eventually, we only could publish the shortened version Rolski and Stoyan (1974), which probably nobody ever has read. However, Tomasz could write his thesis published in Rolski (1976). Unfortunately, I could not attend his defense in December 1973 (confirmed by the Faculty Council in January 1974). But we learned our lesson: We published later the paper Rolski and Stoyan (1976), in the very influential journal *Operations Research.* Finally, we (the whole Stoyan family) met Tomasz again in 1975 when he helped us to spend some days of holiday in Karpacz, the well-known Silesian mountain resort.

## The Theory of PMP

In May 1976 Tomasz was again in Germany. He was now close to his 30th birthday, a young promising scientist with doctoral degree and exploring a new field of research in queueing theory. He visited the Siebenlehn conference on queueing theory, probably as the only foreign guest under around 30 East German participants. Siebenlehn is a small town 17 km from Freiberg in Saxony, where was in G.D.R. time a conference centre, which belonged to the Bergakademie Freiberg, where I was then employed. This centre was rather primitive in comparison to modern times, yet had a very free and stimulating atmosphere comparable with that in Oberwolfach. In that time queueing theory was considered very important in the G.D.R., there were strong groups in Berlin (under Peter Franken), Freiberg (under Dieter König) and Leipzig (under Hans-Joachim Rossberg) and many single researchers scattered in the G.D.R. Simultaneously the application of point process methods had its second high-tide, after the pioneering work of Klaus Matthes with respect to insensitivity (independence of stationary state probabilities on the form of service distributions if mean fixed). For example, it was then known that the formula $L = \lambda W$ can be proved by means of the Campbell's theorem, see Franken (1976).

In that time Tomasz was not only closely related with me. He had a further German friend, Volker Schmidt, aged in 1976 27 years. Together with a group of East German students Schmidt had studied mathematics at Wrocław University and where he met Tomasz. After his study in Poland he got a position as research assistant at Bergakademie Freiberg. (Tomasz' contacts with Volker Schmidt culminated in the book Rolski et al., 2000.)

Thus it was natural to invite Tomasz, while it was unthinkable to invite colleagues from the West. His first talk on Thursday was still heading towards order relations, now for queues with group arrivals. However, he spoke again on Friday, now on a paper by Kuczura (1973) and on two of his own papers (Jankiewicz and Rolski, 1976, and Rolski, 1977) on piecewise Markov processes, regenerative points and infinitesimal operators. I took three pages of handwritten notes. In the point-process-saturated atmosphere of Siebenlehn of that day we felt that there is potential for a systematic generalization using point process methods. It became clear that Tomasz would cooperate with Freiberg instead of Berlin (Peter Franken).

Surprisingly Tomasz could extend his stay in the G.D.R. So, in the next week (the last week of May 1976) long scientific discussions took place in Freiberg. There was a *session room* with a large oak table and a large green blackboard. We all were young then: Dieter König, the head of the group on stochastic models at Bergakademie Freiberg, was 44 and I was 36 years old. It was natural that the Freiberg people dominated the discussions, Tomasz was still very young and only one out of four. He gave a long lecture on Monday in Freiberg while I took five pages handwritten notes. König, a student of Matthes, then explained the theory of marked point processes in the style of his master, what was tough to understand for poor Tomasz. (Nevertheless, he was better informed than me: One of his remarks let me write:"Read Daley, Vere-Jones." Until this instant also my main source was Matthes' work.) König could refer to a paper by himself, Schmidt and me, were we had already studied relationships for stationary distributions related to regenerative points and arbitrary points, see König et al. (1976). So step by step a forthcoming paper formed, with main contributions from Tomasz and Volker Schmidt. I think I remember that Tomasz and I sometimes groaned because of the increasing technical burden for ideas that originally were not so difficult ideas. However, we figured out a plan for the paper and Tomasz went home. We decided to call the discussed processes *stochastic processes with imbedded marked point processes* and used the abbreviation PMP as in this sections heading. The paper was then submitted in February 1977 to the G.D.R. journal *Math. Operationsforsch. Statist., Ser. Optimization.*. Today I believe that this journal and the heavily technical style were the reasons that this paper did not have the influence it deserved. Had a native speaker written it in a less technical style and submitted to a journal such as *J. Applied Probability*, the outcome would probably have been much more favourable.

## A Visit to My Past

On April 1, 2001, I met Tomasz for the last time in person. He helped me to refresh childhood memories from Lower Silesia.

We met in Görlitz at the German-Polish border. By now he had become a clever gentlemanly professor with a strong car and the same hair-do as me. He drove my wife Helga and me fast and straight to a now Polish village, which I remember under the German name Waldheim. (The modern Polish name is Przyborow, the German name was introduced in 1926.) In this village there is a manor-house, build by a German nobleman in the early 19th century in neoclassical style. And in some rooms of this beautiful building my family lived from summer 1943 until end of January 1945.

My parents lived before the war in Berlin and I was born in Berlin. My father was a simple electrical engineer, working at the big German firm Telefunken. He took part of the German Radar research and therefore did not serve as soldier. During World War II, Telefunken did its research in Lower Silesia in the former monastery Leubus (Polish: Lubiąż). Consequently, and also to escape the bombing of Berlin, my family went to Silesia. On January 25, 1945, this time ended, we escaped to Central Germany. I was a five years old boy and have of course memories of Waldheim.

In later years I avoided to visit Waldheim again, but in 2001 the time was ripe. Fortunately, my mother was still living (my father died at the end of war as a civilian) and could comment my report on the visit. And Tomasz' cleverness and understanding was very helpful. He found the manor-house without problems, which was in a relatively good state, and gave me enough time to see everything. I saw a banknote changing hands, which even opened us the door of the manor-house. We could enter our old flat, now empty. We even saw the door-step over which, as she told herself, my mother gave birth to my youngest brother in the heat of August 1943.

We then went together to the riverbank of the Odra (Oder) river, where we had spent many happy hours in the summers of 1943 and 1944, as old photos stand witness for.

I will forever be grateful to Tomasz for his patience and understanding. In the evening we arrived in Wrocław and enjoyed Tomasz' and his wife's hospitality. The next day I gave a talk at Wrocław University, my second after 1975. I had the pleasure to meet and speak with the prominent Wrocław probability and statistics people.

As a footnote I can add that we, Tomasz, a famous American queueing theorist named Richard Serfozo and I, wrote in 2015 a joint paper on the service-time ages and residuals in the $M/G/\infty$ queue, using techniques of point process theory, as retired professors.

## References

Franken, P. (1976). Einige Anwendungen der Theorie zufälliger Punktprozesse in der Bedienungstheorie. *Math. Nachrichten* 70, 309–319.

Jankiewicz, M., and Rolski, T. (1976). Piecewise Markov processes on a general state space. *Zastosowania Mat.* 15, 421–436.

König, D., Rolski, T., Schmidt, V., and Stoyan, D. (1978). Stochastic processes with imbedded Marked point processes (PMP) and their application in queueing. *Math. Operationsforsch. Statist., Ser. Optimization.* 9, 125–141.

König, D., Schmidt, V., and Stoyan, D. (1976). On some relations between stationary distributions of queue lengths and imbedded queues lengths in G/G/s queueing systems. *Math. Operationsforsch. u. Statist.* 7, 577–586.

Matthes, K. (1962) Zur Theorie der Bedienungsprozesse. In: *Trans. of the 3rd Prague Conf. on Information Theory, Stat. Dec. Fns. and Random Processes*, 513–528.

Müller, A., and Stoyan, D. (2002). *Comparison Methods for Stochastic Models and Risks.* J. Wiley & Sons, Chichester.

Rolski, T. (1972). On some inequalities for GI/M/n queues. *Zastosowania Mat.* 13, 43–47.

Rolski, T. (1976). Order Relations in the Set of Probability Distribution Functions and their Application in Queueing Theory. *Dissertationes Math.* 132.

Rolski, T. (1977). A relation between imbedded Markov chains in piecewise Markov processes. *Bull. de L'Acad. Polonais des Sci. Ser. Sci. Math. Astronom. Phys.* 25, 181–189.

Rolski, T., and Stoyan, D. (1974). Two classes of semi-orderings and their application on queueing theory. *Zeit. angew. Math. Mech.* 54, 127–128.

Rolski, T., Schmidli, H., Schmidt, V., and Teugels, J.J. (2000). *Stochastic Processes for Insurance and Finance.* J. Wiley & Sons, Chichester

Rolski, T., Serfozo, R., and Stoyan, D. (2015). Service-time ages, residuals, and lengths in a $M/G/\infty$ service system. *Queueing Systems* 79, 173–181.

Stoyan, D. (1972). Abschätzungen für die Bedienungs- und Zuverlässigkeitstheorie. *Zastosowania Mat.* 13, 173–185.

# “That was no worse than the *Ostsee* in summer.”

*Bob Foley*

I first had the pleasure of meeting Tomek (and Rysiek, Władek, Prof. Łukasiewicz, Masakiyo Miyazawa, Prof. Jaiswal and many others) at the first queueing conference in Karpacz. Peter Franken and Rolf Schassberger debated the strengths of the economies of East and West Germany. Rolf suggested that the East German economy was similar to the hair on Peter's head, which was rather sparse. Peter countered that the East German economy had a better foundation while stroking his full beard. Elja Arjas won a bottle of brandy for solving an open problem posed by Prof. Korolyuk. Counting only the above, there were researchers from at least 8 countries at the conference. Exactly two weeks before the start of the conference, the authorities had demanded the date and place of birth of every conference attendee. This was when it took weeks for a letter from overseas to reach Wrocław, and when it arrived it had already been opened and placed in a little plastic bag. Prof. Łukasiewicz came up with a clever, elegant solution to this version of the birthday problem. I'll leave it to others to describe the solution. I'll bet that Tomek remembers; he may have even helped solve it.

After the conference in Karpacz, our paths crossed multiple times in the U. S., Poland, and Australia. Tomek and I were in Canberra during the—I want to say summer, but in Australia it was the winter. We had talked about seeing Mt. Kosciuszko, but never made it there. We decided to go to the ocean and go swimming. The Australians told us we were crazy; it was winter, and it was much too cold to go swimming. Nevertheless, we rented a car, and three of us drove about 150 km from Canberra to the coast at Bateman's bay.

We found a beautiful, sandy beach that went on for miles. The only other person in the water was surfing while wearing a wetsuit from neck to wrist to ankle. Despite the warnings, we had a wonderful time swimming and body surfing. The water was cold, but not intolerable.

When we exited the ocean and were heading up the beach to the car, Tomek said “That was no worse than the *Ostsee* in summer.”

I replied “Yeah, that was no worse than Lake Huron in summer.”

We were feeling smug about having proven the naysayers wrong, but I was looking forward to a dry towel and clothes. The wind was making it feel a lot colder out of the water. When we reached the car, we discovered that the third person had locked the car with our stuff inside and disappeared. We shivered in the cold wind for a long, long time.

# A letter from Ton Dieker

*Ton Dieker*

Dear Tomek,

I offer my heartfelt congratulations with this fantastic milestone you have achieved!

We first met when I visited Wroclaw in December 2014 as a PhD student. I have wonderful memories from those two weeks, not in the least since it was my very first research visit and I had never collaborated with researchers from outside my group at CWI. I remember being in your office when we were working with Krzys and we suddenly realized that we had made an important discovery. I found that moment in front of your whiteboard so exciting, and it was so great to experience that together! Eventually that insight led to a joint paper in Mathematics of Operations Research.

That visit was also noteworthy because I enjoyed the hospitality that would characterize all my future visits to Wroclaw. We took your dog for long walks at your weekend house near the Czech border, where we also savored Maka's fantastic foods and home-made fruit liquors. Another highlight of my visits to Wroclaw is the opera house. When we went there for the first time (I believe for the Magic Flute), I didn't understand anything because I didn't know the dialogs would be in Polish! I should have done my homework...

Thanks for all of those wonderful memories and for being so supportive to young researchers. Here's to many more years! Ton

Figure 1: Reinhard Bergmann, Daryl Daley, Dietrich Stoyan and Tomasz Rolski, Binz, 1978.

# Stochastic Models V

| | Monday, Sept 12 | | Tuesday, Sept 13 | Wednesday, Sept 14 | Thursday, Sept 15 | Friday, Sept 16 |
|---|---|---|---|---|---|---|
| 8.45-9.00 | Welcome | | | | Opening special session | |
| Chair | G. Last | | J.A. Fill | S. Asmussen | Z. Palmowski | S. Foss |
| 9.00-9.25 | **I. Molchanov** | 9.00-9.25 | **G. Last** | **J. A. Fill** | **D. Daley** | **H. Albrecher** |
| 9.30-9.55 | **J. Ivanovs** | 9.30-9.55 | **M. Mandjes** | **B. Zwart** | **S. Asmussen** | **D. Korshunov** |
| 10.00-10.25 | **R. Loeffen** | 10.00-10.25 | **D. Yogeshwaran** | **P. Lorek** | **S. Foss** | **B. Basrak** |
| 10.30-11.15 | Coffee | | Coffee | Coffee | Coffee | Coffee |
| Chair | G. Samorodnitsky | | T. Mikosch | D. Daley | K. Dębicki | M. Miyazawa |
| 11.15-11.40 | **T. Mikosch** | 11.15-11.40 | **G. Samorodnitsky** | **C. Constantinescu** | **O. Boxma** | **H. Daduna** |
| 11.45-12.10 | **N. Bauerle** | 11.45-12.10 | **A. Bhattacharaya** | **M. Vlasiou** | **M. Miyazawa** | **P. Liu** |
| 12.15-12.40 | **E. Baurdoux** | 12.15-12.40 | **Ł. Kruk** | **B. Jasiulis** | **N. Miyoshi** | **E. Hashorva** |
| 13.00 | Lunch | | Lunch | Lunch | Lunch | Lunch |
| 15.45-16.15 | Coffee | 15.45-16.15 | Coffee | 13.30 Excursion to Poznań | Coffee | |
| Chair | M. Mandjes | | O.Boxma | | B. Błaszczyszyn | |
| 16.15-16.35 | **J. Heiny** | 16.15-16.40 | **I. Czarna** | | **V. Anantharam** | |
| 16.35-16.55 | **P. Markowski** | 16.45-17.10 | **L. Wang** | | **Z. Puchala** | |
| 16:55-17.15 | **P. Dyszewski** | 17.15-17.40 | **L. Ji** | | | |
| 17:15-17:35 | **J. Tumilewicz** | | | 18.30 BARBECUE | 18:00 DINNER | |