Workshop on Lévy processes and time series

in honour of Peter Brockwell and Ross Maller

Program and Abstracts

September 11 – 15, 2017
Ulm, Germany

Program

Monday, September 11, 2017

08:55 - 09:00 *Opening*

09:00 - 09:40 Tony Pakes: The Lambert-W function and infinite divisibility

09:40 - 10:20 Ron Doney: Cramér's Estimate for a reflected Lévy process, revisited

10:20 - 10:50 *Coffee break*

10:50 - 11:30 Gernot Müller: Modelling electricity prices using processes with time-varying parameters

11:30 - 12:10 Dilip Madan: Enterprise, capital, and risk

12:10 - 12:40 Imma Curato: Weak dependence and GMM estimation for supOU and mixed moving average processes

12:40 - 14:00 *Lunch break*

14:00 - 14:40 Rainer Dahlhaus:Towards a general theory for non-linear locally stationary processes

14:40 - 15:20 Jens-Peter Kreiß: Estimated Wold representation and spectral density-driven bootstrap for time series

15:20 - 15:50 *Coffee break*

15:50 - 16:30 Priscilla Greenwood: The Martintote, revisited

16:30 - 17:10 Charles Goldie: A zero-one law for discounted tail series

17:10 - 19:00 *Reception and Poster Section*

Abdulkahar Mohamed Alkadour: Periodic stationary Ornstein-Uhlenbeck processes

David Berger:Some results on moving average random fields, especially CARMA random fields
Viet Son Pham: Lévy-driven CARMA-type processes on the plane
Helmut Pitters: Preferential attachment and the arcsince coalescent
Thiago do Rêgo Sousa: Estimation of the COGARCH process an auxiliary AR representation for the squared returns
Johanna Vestweber: Geometric Ergodicity of the Multivariate Continuous-time GARCH(1,1) Process
Philip Weißmann: Lévy processes conditioned to avoid an interval

Tuesday, September 12, 2017

09:00 - 09:40 Andreas Kyprianou: Sphere stepping algorithms for Dirichlet-type problems with the fractional Laplacian

09:40 - 10:20 Boris Buchmann: Weak subordination of multivariate Lévy processes

10:20 - 10:50 *Coffee break*

10:50 - 11:30 Sid Resnick: Trimming a Lévy subordinator

11:30 - 12:10 Peter Kevei: Trimmed Lévy processes

12:10 - 12:40 Ross Maller: Friends, Colleagues, Countrymen

12:40 - 14:00 *Lunch break*

14:00 - 14:40 Ana Ferreira: Estimation under block maxima and peaks-over-threshold

14:40 - 15:20 Tiandong Wang: Multivariate regular variation for in- and out-degrees in a preferential attachment network model

15:20 - 15:50 *Coffee break*

15:50 - 16:30 Tanja Schindler: Convergence to extremal processes for Lévy processes with slowly varying canonical measure

16:30 - 17:10 Claudia Klüppelberg: Semiparametric estimation of space-time extremes

Wednesday, September 13, 2017

09:00 - 09:40 Qiwei Yao: Testing for high-dimensional white noise

09:40 - 10:20 Howell Tong: From Fibonacci to NeSSa

10:20 - 10:50 *Coffee break*

10:50 - 11:30 Yasumasa Matsuda: Nonstationary extension of CARMA random fields

11:30 - 12:10 Yuzo Hosoya: Measures of time-series interdependence: inference and application

12:10 - 12:40 Peter Brockwell: As it happened

15:00 *Free afternoon, guided city tour*

Thursday, September 14, 2017

09:00 - 09:40 Gerold Alsmeyer: Fluctuation theory for Markov random walks and random difference equations

09:40 - 10:20 Anita Behme: Hitting probabilities of a multivariate compound Poisson model with bipartite graph structure

10:20 - 10:50 *Coffee break*

10.50 - 11:30 Jean Bertoin: Ergodic aspects of some Ornstein-Uhlenbeck type processes related to Lévy processes

11:30 - 12:10 Mladen Savov: Bernstein-gamma functions and exponential functionals of Lévy processes

12:10 - 12:40 Dirk Brandes: On the sample ACF of a Lévy driven moving average process when sampled at a renewal sequence

12:40 - 14:00 *Lunch break*

14:00 - 14:40 Wai Keung Li: Realized covariance matrices modelling based on the matrix-F distribution

14:40 - 15:20 David Stoffer: Some problems in fitting nonlinear time series models

15:20 - 15:50 *Coffee break*

15:50 - 16:30 Alexander Szimayer: Dependent subordination of multivariate Lévy processes using positive Lévy copulas

16:30 - 17:10 Jan Hannig: Model selection using generalized fiducial inference

19:00 *Conference dinner, restaurant Drei Kannen*

Friday, September 15, 2017

09:00 - 09:40 Nick Bingham: Prediction and rigidity

09:40 - 10:20 Anthony Brockwell: A Stochastic Differential Equation view of Kelly's Formula

10:20 - 10:50 *Coffee break*

10:50 - 11:30 Victor Rivero: Deep factorisation of the stable process: radial excursion theory and the point of closest reach

11:30 - 12:10 Uwe Einmahl: A general LIL result for sums of i.i.d. random vectors and the small time LIL behavior of multidimensional Lévy processes at zero

12:10 - 13:30 *Lunch Break*

13:30 - 14:10 Richard Davis: Models for time series of counts with shape constraints

14:10 - 14:50 David Mason: The story of my collaboration with Ross Maller

Talks

Gerold Alsmeyer, Münster University, Germany

Fluctuation theory for Markov random walks and random difference equations

Abstract:
The stability of a random difference equation in a Markovian environment, i.e. of

$$X_n = A_n X_{n-1} + B_n, \quad n = 1, 2, \ldots$$

for a $\mathbb{R}^2$-valued sequence $(A_n, B_n)_{n\geq 1}$ which is modulated by a positive recurrent Markov chain $(M_n)_{n\geq 0}$, is closely related to the fluctuation-theoretic properties of the Markov random walk $(M_n, S_n)_{n\geq 0}$, where $S_n = \sum_{k=1}^{n} \log |A_k|$. In the case of i.i.d. (A_n, B_n), Goldie and Maller [4] provided necessary and sufficient conditions for the existence of a unique stationary distribution of $(X_n)_{n\geq 0}$ in terms of $(S_n)_{n\geq 0}$ and B_n. An extension of their result to the Markov-modulated situation will be given in this talk after the presentation of extensions of classical fluctuation-theoretic results, most notably of theorems due to Spitzer and Erickson [3] and [6] and to Kesten and Maller [5]. The positive recurrent driving chain $(M_n)_{n\geq 0}$ is supposed to have countable state space.

This is joint work with Fabian Buckmann.

References:

[1] Alsmeyer, G. and Buckmann, F. (2017) Stability of perpetuities in Markovian environment. *J. Difference Equ. Appl.* **23**, 699–740.

[2] Alsmeyer, G. and Buckmann, F. (2017) Fluctuation theory for Markov random walks. *J. Theoret. Probab.*, to appear.

[3] Erickson, K.B. (1974) The strong law of large numbers when the mean is undefined. *Trans. Amer. Math. Soc.* **185**, 371–381.

[4] Goldie, C.M. and Maller; R.A. (2000) Stability of perpetuities. *Ann. Probab.* **28**, 1195–1218.

[5] Kesten, H. and Maller, R.A. (1996) Two renewal theorems for general random walks tending to infinity. *Probab. Theory Related Fields* **106**, 1–38.

[6] Spitzer, F. (1956) A combinatorial lemma and its application to probability theory. *Trans. Amer. Math. Soc.* **82**, 323–339.

Anita Behme, TU Dresden, Germany

HITTING PROBABILITIES OF A MULTIVARIATE COMPOUND POISSON MODEL WITH BIPARTITE GRAPH STRUCTURE

Abstract:
We investigate hitting probabilities of a multivariate compound Poisson process whose dependency structure is encoded by a random bipartite graph. We derive a network Pollaczek-Khinchine formula and Lundberg bounds for the hitting probabilities and discuss the network influence on these. Natural applications are ruin probabilities in a risk sharing network and buffer overflow in a queueing network.

This talk is based on joint work with Claudia Klüppelberg and Gesine Reinert.

Jean Bertoin, University Zürich, Switzerland

ERGODIC ASPECTS OF SOME ORNSTEIN-UHLENBECK TYPE PROCESSES RELATED TO LÉVY PROCESSES

Abstract:
This talk concerns the Ornstein-Uhlenbeck type process associated to a positive self-similar Markov process $(X(t))_{t\geq 0}$ which drifts to ∞, namely $U(t) := \mathrm{e}^{-t}X(\mathrm{e}^t-1)$. We shall see that U is always a (topologically) recurrent Markov process and identify its invariant measure in terms of the law of the exponential functional $\hat{I} := \int_0^\infty \exp(\hat{\xi}_s)\mathrm{d}s$, where $\hat{\xi}$ is the dual of the real-valued Lévy process ξ related to X by the Lamperti transformation. This invariant measure is infinite (i.e. U is null-recurrent) if and only if $\xi_1 \notin L^1(\mathbb{P})$. In that case, we determine the family of Lévy processes ξ for which U fulfills the conclusions of the Darling-Kac theorem. Our approach relies crucially on another generalized Ornstein-Uhlenbeck process [1] that can be associated to the Lévy process ξ, namely $V(t) := \exp(\xi_t)\left(\int_0^t \exp(-\xi_s)\mathrm{d}s + V(0)\right)$, and properties of time-substitutions based on additive functionals.

References:

[1] Lindner, A. and Maller, R. (2005) Lévy integrals and the stationarity of generalised Ornstein-Uhlenbeck processes.*Stochastic Process. Appl.* **115**, 1701–1722.

Nick Bingham, Imperial College London, United Kingdom

PREDICTION AND RIGIDITY

Abstract:
In prediction for stationary time series, we focus on non-determinism (ND, or Szegö's condition), pure non-determinism (PND – ND + no singular part) and complete non-determinism (CND – the rigidity of our title). We link this with Nehari sequences, and give related versions of Baxter's theorem and the strong Szegö limit theorem.

Dirk-Philip Brandes, Ulm University, Germany

ON THE SAMPLE AUTOCOVARIANCE OF A LÉVY DRIVEN CONTINUOUS TIME MOVING AVERAGE PROCESS SAMPLED AT A RENEWAL SEQUENCE

Abstract:
We consider a Lévy driven continuous time moving average process X sampled at random times which follow a renewal structure independent of X. We show that the strict stationarity property of the process X is inherited by the sampled process. Asymptotic normality of the sample mean, the sample autocovariance, and the sample autocorrelation is established and sufficient conditions on the kernel and the random times are given. We compare our results to a classic non-random equidistant sampling method as done in [3] and give an application to parameter estimation of the generalized Ornstein-Uhlenbeck process.

This talk is based on joint work with Imma Curato.

References:

[1] Bradley, R. C. (2007) *Introduction to Strong Mixing Conditions, Volume 1*, Kendrick Press, Utah.

[2] Brockwell, P.J. and Davis, R.A. (2006) *Time Series: Theory and Methods*. 2nd ed, Springer, New-York.

[3] Cohen, S. and Lindner, A. (2013) A central limit theorem for the sample autocorrelations of a Lévy driven continuous time moving average process. *J. Stat. Plan. Inference* **143**, 1295–1306.

Anthony Brockwell, Two Sigma Investment, USA

A Stochastic Differential Equation view of Kelly's Formula

Abstract:
Kelly's formula was given by J. L. Kelly in 1956 to determine the optimal size of a bet. In this talk we point out that it can also be derived for a geometric Brownian motion using basic Ito calculus. We then carry out some simple data analysis to see what kind of leverage Kelly's formula would prescribe in a real-life setting, assuming an investor is able to invest using leverage in assets whose prices are governed by GBM. We discuss and critique the ensuing results.

Boris Buchmann, ANU, Australia

Weak Subordination of Multivariate Lévy Processes

Abstract:
Subordinating a multivariate Lévy process, the subordinate, with a univariate subordinator gives rise to a pathwise construction of a new Lévy process, provided the subordinator and the subordinate are independent processes. The variance-gamma model in finance was generated accordingly from a Brownian motion and a gamma process. Alternatively, multivariate subordination can be used to create Lévy processes, but this requires the subordinate to have independent components.

In this talk, we show that there exists another operation acting on pairs (T,X) of Lévy processes which creates a Lévy process $X \odot T$. Here, T is a subordinator, but X is an arbitrary Lévy process with possibly dependent components. We show that this method is an extension of both univariate and multivariate subordination and provide two applications. We illustrate our methods giving a weak formulation of the variance-α-gamma process that exhibits a wider range of dependence than using traditional subordination. Also, the variance generalised gamma convolution class of Lévy processes formed by subordinating Brownian motion with Thorin subordinators is further extended using weak subordination.

Imma Curato, Ulm University, Germany

Weak Dependence and GMM Estimation for supOU and mixed moving average processes

Abstract:
We consider a mixed moving average process X driven by a Lévy basis and show that it is a weakly dependent process. Using this property, we show that sample mean and autocovariances of X have a limiting normal distribution. As an application, we can then apply a Generalized Method of Moments estimation for the supOU process and the supOU stochastic volatility model after choosing a suitable distribution for the mean reverting parameter. For these estimators we analyze the asymptotic behavior in detail.

This talk is based on joint work with Robert Stelzer.

Rainer Dahlhaus, University of Heidelberg, Germany

Towards a general theory for non-linear locally stationary processes

Abstract:
In this paper some general theory is presented for locally stationary processes based on the stationary approximation and the stationary derivative. Strong laws of large numbers, central limit theorems as well as deterministic and stochastic bias expansions are proved for processes obeying an expansion in terms of the stationary approximation and derivative. In addition it is shown that this applies to some general nonlinear non-stationary Markov-models. In addition the results are applied to derive the asymptotic properties of maximum likelihood estimates of parameter curves in such models. The approach is also used to derive results on adaptive bandwidth selectoin via cross validation for local M-estimators in locally stationary processes.

joint work with Stefan Richter and Wei Biao Wu.

Richard A. Davis, Columbia University, USA

MODELS FOR TIME SERIES OF COUNTS WITH SHAPE CONSTRAINTS

Abstract:
In recent years there has been growing interest in modeling time series of counts. Many of the formulated models for count time series are expressed via a pair of generalized state-space equations. In this set-up, the observation equation specifies the conditional distribution of the observation Y_t at time t given a *state-variable* X_t. For count time series, this conditional distribution is usually specified as coming from a known parametric family such as Poisson, negative binomial, etc. To relax this formal parametric framework, we introduce a shape constraint into the one-parameter exponential family. This essentially amounts to assuming that the *reference measure* is log-concave. In this fashion, we are able to extend the class of observation-driven models studied in Davis and Liu (2016). Under this formulation, there exists a stationary and ergodic solution to the state-space model. In this new modeling framework, we compute and maximize the likelihood function over both the parameters associated with the mean function and the reference measure subject to a concavity constraint. The estimator of the mean function and the conditional distribution are shown to be consistent and perform well compared to a full parametric model specification. The finite sample behavior of the estimators are studied via simulation and two empirical examples are provided to illustrate the methodology.

This talk is based on joint work with Jing Zhang.

Ron Doney, Manchester University, United Kingdom

CRAMÉR'S ESTIMATE FOR A REFLECTED LÉVY PROCESS, REVISITED

Abstract:
We survey, correct and extend some Cramér-type estimates for the reflected process of a Lévy process, also known as the drawup in mathematical finance.

This talk is based on joint work with Phil Griffin.

Uwe Einmahl, Free University Brussel, Belgium

A general LIL result for sums of i.i.d. random vectors and the small time LIL behavior of multidimensional Lévy processes at zero

Abstract:
Let $\xi_1, \xi_2, \ldots$ be i.i.d. mean zero random vectors in $\mathbb{R}^d$ with finite second moments. Set $S_n = \sum_{j=1}^n \xi_j, n \geq 1$. Then it is well known that with probability one, $\limsup_{n\to\infty} |S_n|/\sqrt{2\log\log n} = \sigma$, where σ^2 is the largest eigenvalue of the covariance matrix of X_1.

It is a classical problem of probability wether one can find analogous results in in the infinite second moment case. In a relatively recent paper [2] necessary and sufficient conditions were found for having $\limsup_{n\to\infty} |S_n|/\sqrt{2nh(n)} = \lambda$, w.p. 1, where $h : [1,\infty[\to]0,\infty[$ is monotone non-decreasing and slowly varying at infinity.

There is also an LIL for d-dimensional Lévy processes $\{X_t : t \geq 0\}$ as $t \to 0$. In this case we have $\limsup_{t\downarrow 0} |X_t|/\sqrt{2t\log\log 1/t} = \sigma$, where σ^2 is the largest eigenvalue of the matrix Σ in the characteristic triplet (γ, Σ, Π) of the process $\{X_t, t \geq 0\}$. If this matrix is the zero-matrix one has convergence to 0 and it is natural to ask whether one can find smaller normalizing functions $b(t)$ leading in this case to a positive and finite $\limsup$.

This is indeed possible if one chooses the function $b(t) = \sqrt{t}$ (see [1]) and this was later extended to a larger class of functions $b(t)$ in [3].
We follow up the work of these authors and we provide necessary and sufficient conditions for having w. p. 1.

$$\limsup_{t\downarrow 0} h(1/t)\frac{|X_t|}{\sqrt{2t\log\log 1/t}} = \lambda,$$

where h is monotone non-decreasing and slowly varying at infinity.

References:

[1] Bertoin, J., Doney, R.A. and Maller, R.A. (2008). Passage of Lévy processes across power law boundaries at small times. *Ann. Probab.*, **36**, 160–197.

[2] Einmahl, U. and Li, D. (2008). Characterization of LIL Behavior in Banach Space. *Trans. Amer. Math. Soc.* **360**, 6677–6693.

[3] Savov, M. (2009). Small-time two-sided LIL behavior for Lévy processes at zero. *Probab. Theory Rel. Fields* **144**, 79–98.

Ana Ferreira, University of Lisbon, CEMAT, CEAUL, Portugal

Estimation under Block Maxima and Peaks-Over-Threshold

Abstract:
We shall review two fundamental methods in Extreme Value Theory, the Block Maxima (BM) and the Peaks-Over-threshold (POT). Procedures for estimating extreme value parameters have been proposed, including maximum likelihood and probability weighted moment estimation. We shall discuss and compare asymptotic properties from several estimators and consequently compare asymptotic performance of BM and POT approaches.

This talk is based on joint work with Clément Dombry and Laurens de Haan.

Charles M. Goldie, University of Sussex, United Kingdom

A zero-one law for discounted tail series

Abstract:
For i.i.d. (W_i, Z_i) I call the sequence $T_n := \sum_{j=n}^{\infty} W_n \cdots W_{j-1} Z_j$ a discounted tail series. Under suitable conditions I'll prove a zero-one law, namely that for any sequence $u_n \downarrow 0$, $P(T_n < u_n \text{ infinitely often}) = 0$ or 1 according as $\sum_{n=1}^{\infty} P(T_n < u_n) < \infty$ or $= \infty$.

This talk is based on joint work with the late Wim Vervaat.

Priscilla Greenwood University of British Columbia, USA

The Martintote, revisited

Abstract:
In the 1970's there appeared in the Annals of Probability some papers on the asymptotics of distributions produced by random stopping of random sequences (time series). A stochastic process, the Martintote, was defined, an analogue of the Martingale, where conditional

tail behavior plays the role of conditional expectation, and an optional sampling result was established. This very special occasion may be a suitable one for revisiting this circle of ideas.

References:

[1] Greenwood, P. (1973) Asymptotics of randomly stopped sequences with independent increments. *Ann.Probab.* **1**, 317–321.

[2] Greenwood, P. (1974) The Martintote. *Ann.Probab.* **2**, 84–89.

[3] Greenwood, P. and Monroe, I. (1977) Random stopping preserves regular variation of process distributions. *Ann.Probab.* **5**, 42–51.

Jan Hannig, University of North Carolina, USA

Model selection using generalized fiducial inference

Abstract:
In recent years, the ultrahigh-dimensional linear regression problem has attracted enormous attention from the research community. Under the sparsity assumption, most of the published work is devoted to the selection and estimation of the predictor variables with nonzero coefficients. This article studies a different but fundamentally important aspect of this problem: uncertainty quantification for parameter estimates and model choices. To be more specific, we discuss methods for deriving a probability density function on the set of all possible models, and also for constructing confidence intervals for the corresponding parameters. These proposed methods are developed using the generalized fiducial methodology, which is a variant of Fisher's controversial fiducial idea and a new prediction based replacement for penalties. Theoretical properties of the proposed methods are studied, and in particular it is shown that statistical inference based on the proposed methods will have correct asymptotic frequentist property. In terms of empirical performance, the proposed methods are tested by simulation experiments and an application to a real dataset. We will also discuss ongoing work applying this framework to multivariate time series.

This talk is based on joint work with Jonathan William.

Yuzo Hosoya, Tohoku University, Japan

Measures of time-series interdependence: inference and application

Abstract:
In this talk we suggest an approach to analyzing vector time series interdependence with real-life applications in view. The basic idea is the elicitation of a one-way effect component of a supposedly causing series. The measures of one-way effect, reciprocity, and association are defined overall as well as frequency-wise quantities in the frequency domain.

To address the problem of third-series involvement, we introduce a partial version of the measures of interdependence. The third-effect elimination suggested in [3] is the elimination of the one-way effect component of the third series from a pair of subject-matter series to preserve the inherent feedback structure of the pair. We provide explicit representations of the partial measures and show how they are numerically evaluated by means of the canonical factorization algorithm by [5]. Using the stationary vector ARMA process as a specific model, we suggest the statistical estimation of the measures on the basis of the Whittle likelihood function and Monte Carlo testing allied hypotheses, discussing also the asymptotic theory on the basis of [2], [4]. In the talk, we illustrate the performance of a small sample of the Whittle estimate of the partial interdependence measures using simulated data and also provide an empirical analysis of U.S. interest rates and economic growth data; see [1] for a related research.

This talk is based on joint work with Taro Takimoto.

References:

[1] Breitung, J. and Candelon, B. (2006) Testing for short- and long-run causality: A frequency-domain approach, *Journal of Econometrics*, **132**, 363–378.

[2] Hosoya, Y. (1997) A limit theory for long-range dependence and statistical inference on related models, *The Annals of Statistics*, **25**, 105–137.

[3] Hosoya, Y. (2001) Elimination of third-series effect and defining partial measures of causality, *Journal of Time Series Analysis*, **22**, 537–554.

[4] Hosoya, Y. (2005) Fractional invariance principle, *Journal of Time Series Analysis*, **26**, 463–486.

[5] Hosoya, T. and Takimoto, T. (2010) A numerical method for factorizing the rational spectral density matrix, *Journal of Time Series Analysis*, **31**, 229–240.

[6] Hosoya, T., Oya, K., Takimoto, T. and Kinoshita, R. (2017) Characterizing Interdependencies of Multiple Time Series:Theory and Application, to appear in *Springer JSS Research Series in Statistics*.

Péter Kevei, University of Szeged, Hungary

Trimmed Lévy processes

Abstract:
Recently, much attention is payed to trimmed Lévy processes due to the work by Maller and coauthors. In this talk we show two distinct aspects of trimming.

Let V_t be a driftless subordinator, and let denote $m_t^{(1)} \geq m_t^{(2)} \geq \dots$ its jump sequence on interval $[0,t]$. Put $V_t^{(k)} = V_t - m_t^{(1)} - \dots - m_t^{(k)}$ for the k-trimmed subordinator. In the first part of the talk we characterize under what conditions the limiting distribution of the ratios $V_t^{(k)}/m_t^{(k+1)}$ and $m_t^{(k+1)}/m_t^{(k)}$ exist, as $t \downarrow 0$ or $t \to \infty$.

In the second half of the talk we consider sums of iid St. Petersburg random variables, i.e. the common distribution is $P(X = 2^k) = 2^{-k}$, $k = 1, 2, \dots$. The St. Petersburg distribution is not in the domain of attraction of any stable law. The limiting distributions along geometrically increasing subsequences of centralized and normalized St. Petersburg sums are semistable laws. We provide exact tail asymptotics for the k-trimmed sum of iid St. Petersburg random variables, and for the limiting k-trimmed semistable laws.

This talk is based on joint work with David Mason, István Berkes and László Györfi.

Claudia Klüppelberg, TU München, Germany

Semiparametric estimation of space-time extremes

Abstract:
Max-stable space-time processes have been developed to study extremal dependence in space-time data. We propose a semiparametric estimation procedure based on a closed form expression of the extremogram to estimate the parameters in a max-stable space-time process. We establish the asymptotic properties of the resulting parameter estimates based on a CLT

for the empirical extremogram. We also propose subsampling procedures to obtain asymptotically correct confidence intervals. A simulation study shows that the proposed procedure works well for moderate sample sizes. Finally, we apply this estimation procedure to fitting a max-stable model to radar rainfall measurements in a region in Florida.

This talk is based on joint work with Sven Buhl, Richard Davis, and Christina Steinkohl.

References:

[1] Buhl, S., Davis, R.A., Klüppelberg, C. and Steinkohl, C. (2016) Semiparametric estimation for isotropic max-stable space-time processes. Submitted.

[2] Buhl, S. and Klüppelberg, C. (2016) Limit theory for the empirical extremogram of random fields. Submitted.

[3] Buhl, S. and Klüppelberg, C. (2016) Generalised least squares estimation of regularly varying space-time processes based on flexible observation schemes. Submitted.

Jens-Peter Kreiß, TU Braunschweig, Germany

EstimatedWold Representation and Spectral Density-Driven Bootstrap for Time Series

Abstract:
The second-order dependence structure of purely nondeterministic stationary process is described by the coefficients of the famous Wold representation. These coefficients can be obtained by factorizing the spectral density of the process. This relation together with some spectral density estimator is used in order to obtain consistent estimators of these coefficients. A spectral density-driven bootstrap for time series is then developed which uses the entire sequence of estimated moving average coefficients together with appropriately generated pseudo innovations in order to obtain a bootstrap pseudo time series. It is shown that if the underlying process is linear and if the pseudo innovations are generated by means of an i.i.d. wild bootstrap which mimics, to the necessary extent, the moment structure of the true innovations, this bootstrap asymptotically works for a wide range of statistics. The relations of the proposed bootstrap procedure to some other bootstrap procedures, including the autoregressive-sieve bootstrap are discussed. It is shown that the latter is a special case of the spectral density-driven bootstrap proposed, when a parametric autoregressive

spectral density estimator is used. Simulations investigate the performance of the new bootstrap procedure in finite sample situations. Furthermore, a real-life data example is presented.

This talk is based on joint work with Jonas Krampe and Efstathios Paparoditis.

Andreas Kyprianou, University of Bath, United Kingdom

Sphere stepping algorithms for Dirichlet-type problems with the fractional Laplacian

Abstract:
We review the sphere-stepping algorithm for simulating the solution to the classical Dirichlet problem and consider whether the same can be done when the Laplacian can be changed to the fractional Laplacian. Whereas in the former case, we need knowledge about isotropic Brownian motion, in the latter case, we need information about isotropic stable Levy processes. We will show that the stable case offers a *faster* convergence than in the Brownian case thanks to the trajectory of stable processes having jumps.

Wai Keung Li, Hong Kong University, China

Realized covariance matrices modelling based on the matrix-F distribution

Abstract:
Realized covariance matrices (RCOV), as the multivariate extension to realized volatilities, have drawn great attention from econometrics and statistics researchers. From high frequency trading data, estimated RCOV can be utilized as a promising measure on the underlying covariance structure of low frequency returns. This motivates the need in modeling and forecasting the RCOV's. This talk provides a complete parametric framework on modeling the temporal dependency of RCOV based on the matrix-F distribution. We establish the stationarity condition of the proposed model, and the asymptotic distribution of estimated parameters. In addition, diagnostic tests are constructed to examine the adequacy

of the fitted model. In real data analysis, with CAW model as the baseline, we conduct Diebold-Mariano tests and conclude that our proposed model can achieve significant better forecasting performance.

Dilip Maden, University of Maryland, USA

Enterprise, Capital, and Risk

Abstract:
Economic enterprises are represented by their return processes modeled in efficient markets by pure jump limit laws. In particular four parameters of a bilateral gamma process are used to synthesize the up and down moves with differing mean and variance rates for the two motions. Prudential capital requirements value a distant terminal payout given by accumulated returns. The valuation incorporates risk charges based on measure distortions generalizing distorted expectations. The risk charges are calibrated to data on S&P 500 index options and their associated time series. Regulatory capital evaluates extreme loss levels possible in a short interval. For the equity space the two calculations yield comparable magnitudes displaying enterprises with sufficient and insufficient capital. Enterprises invested in Treasury bonds have regulatory capital is well below their prudential capital levels for long positions. Short positions may have insufficient prudential capital values relative to their regulatory counterparts. The additional prudential and regulatory capital costs of leveraged positions are illustrated. Hedge funds reflect high levels of prudential capital associated with low levels of required regulatory capital reflecting the access of good drifts at low risk levels.

David M. Mason, University of Delaware, USA

The Story of My Collaboration with Ross Maller

Abstract:
My collaboration with Ross began about ten years ago through a chance misdirected e-mail communication. This resulted in a series of strong papers on the characterization of the limiting distribution and laws of the iterated logarithm for self-normalized Levy processes

and stochastic compactness of d-dimensional Lévy processes. I will give an expository survey of some of the highlights of this work, concentrating on our results on the asymptotic distributional behavior and LIL for self-normalized Lévy processes at small time. Boris Buchmann joined us in the LIL study. These results appeared in the TAMS in 2010 and 2015.

Our accidental encounter also led to a number of meetings with kangaroos, wallabies and koala bears in the Australian bush.

Yasumasa Matsuda, Tohoku University, Japan

Nonstationary extension of CARMA random fields

Abstract:
Brockwell and Matsuda [1] extended continuous ARMA (CARMA) models for time series to those for spatial data. In this talk, we aim an nonstationary extension of CARMA random fields by allowing the spectral density functions to be dependent spatially in a similar way with that of Dahlhaus [2]. We propose an efficient estimation procedure based on Whittle likelihoods and derive consistency and asymptotic normality of the estimators, Finally we apply the non-stationary CARMA random fields to US precipitation data, monthly observations of precipitation in around 6000 observatory points scattered all over US continent to demonstrate how it can detect nonstationary variations of US precipitations.
References:

[1] Brockwell, P.J. and Matsuda, Y. (2017) Continuous auto-regressive moving average random fields on R^n. *J. Roy. Stat. Soc., Ser. B.* **79**, 833–857.

[2] Dahlhaus, R. (1997) Fitting time series models to nonstationary process. *Ann. Stat.* **25**, 1–37.

Gernot Müller, University of Augsburg, Germany

Modelling electricity prices using processes with time-varying parameters

Abstract:
The electricity price model developed in Benth et al. (2014) disentangles the spot price into three components: a trend and seasonality function, a CARMA process driven by an alpha-stable Lévy process, and an additional Lévy process for the long-term fluctuations. However, due to changing rules and regulations, changing market conditions, and a changing electricity production towards a higher proportion of renewable energies, electricity prices show a changing behaviour over time. We modify the model from Benth et al. (2014) by employing processes which show locally a behaviour similar to alpha-stable processes, but allow for time-varying parameters. The processes under consideration have no stationary increments, so that we look at additive (i.e. independent increment) processes instead of Lévy processes. To estimate the model we develop an MCMC procedure and assess the quality of this estimation method in a simulation study; in particular, we compare the new method to the stepwise maximum likelihood procedure from Benth et al. (2014). The data which motivates the project is taken from the data base of the European Energy Exchange EEX.

The talk is based on joint work with Boris Buchmann and Armin Seibert.

Anthony G. Pakes, University of Western Australia, Australia

The Lambert-W function and infinite divisibility

Abstract:
It's known that the Lambert-W function is Bernstein and hence is the Laplace exponent of a subordinator (S_t). The Lambert law is the law of S_1. Several proofs are known giving varying degrees of information about the Lambert law. I will review these and also a new proof based on a (little) known integral evaluation which gives more information about the Lambert law.

If time permits, I will discuss a putative continuous version of the generalised Poisson law, also deriving from the Lambert-W, and proposed in an astrophysical context. There is a problem here which I invite others to solve.

References:

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[2] Pakes, A.G. (2011) Lambert's W, infinite divisibility and Poisson mixtures. *J. Math. Anal. Appl.* **378**, 480–492.

[3] Schilling, R.N., Song, R. & Vondracek, Z. (2012) *Bernstein Functions, 2nd. ed.*. De Gruyter, Berlin.

Sidney Resnick, Cornell University, USA

Trimming a Lévy Subordinator

Abstract:
Let $N = \sum_k \epsilon_{j_k}(\cdot)$ be PRM(ν), a Poisson random measure on $(0,\infty)$ with mean measure $\nu(\cdot)$. Suppose $\nu(\cdot)$ is finite in neighborhoods of ∞ with $Q(x) = \nu(x,\infty)$ as the finite tail function. If $\{\Gamma_l, l \geq 1\}$ are unit rate homogeneous Poisson points on $(0,\infty)$ and $\int_0^1 u\nu(du) < \infty$, we may generate a Lévy subordinator $X(t), t \geq 0$ and represent $X = X(1)$ as

$$X = \int_0^\infty uN(du) = \sum_{l=1}^\infty Q^{\leftarrow}(\Gamma_l),$$

a sum of Poisson jumps written in decreasing order. We may peel or trim off the r largest points and define

$${}^{(r)}X = \sum_{l=r+1}^\infty Q^{\leftarrow}(\Gamma_l), \quad Y^{(r)} = Q^{\leftarrow}(\Gamma_r)$$

giving the trimmed Levy random variable and the rth largest jump.

As $r \to \infty$, when does

$$({}^{(r)}X, Y^{(r)})$$

have a limit distribution (with appropriate centering and scaling)? Since it is always true that

$$\frac{{}^{(r)}X - \mu(Y^{(r)})}{\sigma(Y^{(r)})} = \frac{{}^{(r)}X - \int_0^{Y^{(r)}} u\nu(du)}{\int_0^{Y^{(r)}} u^2\nu(du)} \Rightarrow N_X = N(0,1)$$

(since $r \to \infty$ means we mash down the size of the jumps), the answer differs if centerings are allowed to be random or not. With deterministic centerings, extended regular variation must be employed to get a solution.

This talk is based on joint work with Ross Maller, Boris Buchmann and Yugang Ipsen.

References:

[1] Buchmann, B., Maller, R. and Resnick, S. (2016) Processes of rth Largest. *ArXiv e-prints*, `http://adsabs.harvard.edu/abs/2016arXiv160708674B`. Submitted: Extremes.

[2] Ipsen, Y., Maller, R. and Resnick, S. Ratios of Ordered Points of Point Processes with Regularly Varying Intensity Measures. *In preparation*.

[3] Ipsen, Y., Maller, R. and Resnick, S. Joint limit behavior of trimmed subordinators and the rth largest jump. *Forthcoming*.

Victor Rivero, CIMAT, Mexico

Deep factorisation of the stable process: radial excursion theory and the point of closest reach

Abstract:
In this talk we will present some recent results about the d-dimensional stable process and the Markov additive process related to it via Lamperti-Kiu transformation. Analyzing stable processes from the point of view of self-similar Markov processes allows us to both increase our understanding of stable processes and to provide explicit fluctuation theory like identities for the Markov additive process associated to it. For stable process we focus on the distribution of the point of closest reach and develop a radial excursion theory. Moreover, we provide a representation of the Wiener–Hopf factorisation of the MAP that underlies the stable process through the Lamperti–Kiu transform.

Mladen Savov, Bulgarian Academy of Sciences, Bulgaria

Bernstein-gamma functions and exponential functionals of Lévy processes

Abstract:
For any negative definite function Ψ we consider a recurrent equation of the type $f(z+1) = \frac{-z}{\Psi(-z)} f(z)$. Using the Wiener-Hopf factorization of Ψ we solve this equation in a three term product involving the solutions of $W_\phi(z+1) = \phi(z) W_\phi(z)$ on $\{z \in \mathbb{C} : \Re(z) > 0\}$, where ϕ is any Bernstein function. We call W_ϕ a Bernstein-gamma function and note that W_ϕ has appeared in more restricted context in some earlier studies. The Bernstein-gamma functions are characterized as meromorphic functions on an identifiable complex strip. This is achieved in terms of parameters depending on the input function ϕ. Moreover, we establish universal, explicit Stirling type asymptotic of W_ϕ. This allows the thorough understanding of the decay of $|f(z)|$ at least along the imaginary lines $z = a + i\mathbb{R}$, $a \in (0,1)$, and an access to quantities relevant for some theoretical and applied studies in probability theory and other areas. The foremost motivation for the aforementioned results is their application to the study of an important class of non-self-adjoint Markov processes. However, in this talk, as an application, we present some general results on the law of the exponential functional of Lévy processes, that is $\int_0^\infty e^{-\xi_s} ds$, which are a consequence of the understanding of f and the fact that the Mellin transform of the exponential functional satisfies the recurrent equation $f(z+1) = \frac{-z}{\Psi(-z)} f(z)$. We discuss results such as smoothness, large and small asymptotic, expansions, bounds and Mellin Barnes representations. When $\int_0^\infty e^{-\xi_s} ds = \infty$ we study under the Spitzer's condition the weak convergence of the measures induced from $\int_0^t e^{-\xi_s} ds$, as $t \to \infty$. The derivation of our results relies on analytical, complex-analytical and probabilistic techniques.

This talk is based on joint work with Pierre Patie.

References:

[1] Patie, P. and Savov, M. Bernstein-gamma functions and exponential functionals of Lévy processes. *Submitted.*

Tanja Schindler, ANU, Australia

Convergence to extremal processes for Lévy processes with slowly varying canonical measure

Abstract:
A classical result by Feller states that a random walk with regularly varying tails with exponent $\alpha \in (0, 2)$ lies in the domain of attraction of an α-stable law. Kasahara extended this result to the case $\alpha = 0$ in the following way. On the one handside taking an α stable sum process to the power of α and letting α tend to zero, this process converges to the reciprocal of an exponential random variable. On the other hand considering the normed sum process for a random variable with slowly varying tails, this process converges to the reciprocal of an exponential random variable as well.

We transfer the results of Kasahara to continuous time processes for a small time parameter. Furthermore, we generalise these results to trimmed versions of Lévy processes, i.e. we remove a fixed number of largest jumps from the original process.

This is work in progress with Ross Maller.

David Stoffer, University of Pittsburg, USA

Some problems in fitting nonlinear time series models

Abstract:
Inference for nonlinear models can be difficult and often relies on derivative free numerical optimization techniques. Promising methods are based on particle approximations. The methods can be used for both classical inference (e.g., Monte Carlo EM type algorithms) and Bayesian inference (e.g., Gibbs sampler).

Particle methods are an extension of sequential importance sampling (SIS). Although the SIS algorithm has been known since the early 1970s, its use in nonlinear problems remained largely stagnant until the early 1990s. Obviously the available computational power was too limited to allow convincing applications of these methods, but other difficulties plagued the technique. I will discuss a few modern approaches.

Alexander Szimayer, Hamburg University, Germany

Dependent Subordination of Multivariate Lévy Processes using positive Lévy Copulas

Abstract:
We consider positive Lévy copulas to describe the jump dependence between increasing Lévy processes applied as stochastic time-change in Lévy market models. In economic terms, the price process is subject to possibly non-linear dependencies in the marginal market activities, different to simple log-return correlations. Using weak subordination allows for modeling dependencies both in the time and the space dimension while remaining in the class of Lévy processes. We analyze the properties, and present an approach for simulation and likelihood-based estimation. We emphasize novel multivariate variance gamma models, estimate these models based on daily financial data and interpret the results particularly with regard to the dependence of the marginal market activities.

This talk is based on joint work with Markus Michaelsen.

Howell Tong, University of Electronic Science & Technology, China

From Fibonacci to NeSSA

Abstract:
The celebrated Golden Section search algorithm that goes back to Fibonaci is powerful for finding the extremum of a strictly unimodal deterministic function. However, in many statistical problems, we seek the extremum of a *random* function that converges in some sense to a strictly unimodal deterministic function. This talk falls within this general area. It focuses on the estimation of the threshold parameter in a threshold model in time series analysis. A commonly used approach is to do a standard grid search that typically requires $O(n)$ operations for a sample of size n. This talk describes a novel method, the *nested sub-sample search algorithm*, which reduces the number of search drastically to $O(\log n)$ for large sample size.

This talk is based on joint work with Dong Li.

References:

[1] Li, D. and Tong, H. (2016) Nested sub-sample search algorithm for the estimation of threshold models. *Statistica Sinica.* **26**, 1543–1554.

Tiandong Wang, Cornell University, USA

Multivariate Regular Variation for In- and Out-Degrees in a Preferential Attachment Network Model

Abstract:
Preferential attachment is an appealing mechanism for modeling directed social networks. Both empirical evidence and mathematical analysis reveal that in- and out-degree distributions follow a power law. Other than showing the multivariate regular variation of the joint measure, we prove that the joint mass function of normalized in- and out-degree is also regularly varying. We then turn to the parameter estimation of this model using asymptotics. Compared with parametric estimation approaches, this semi-parametric asymptotic method is believed to be more robust against modeling errors.

This talk is based on joint work with Phyllis Wan, Richard Davis and Sidney Resnick.

References:

[1] Wan, P., Wang, T., Daivs, R.A. and Resnick, S.I. (2017) Fitting the Linear Preferential Attachment Model. *Submitted to Electronic Journal of Statistics*.

[2] Wang, T. and Resnick, S.I. (2016) Multivariate Regular Variation of Discrete Mass Functions with Applications to Preferential Attachment Networks. *Methodology and Computing in Applied Probability*, 1–14.

Qiwei Yao, London School of Economics, London, United Kingdom

Testing for High-dimensional White Noise

Abstract:
Testing for white noise is a fundamental problem in statistical inference, as many testing problems in linear modelling can be transformed into a white noise test. While the celebrated Box-Pierce test and its variants tests are often applied for model diagnosis, their relevance in the context of high-dimensional modeling is not well understood, as the asymptotic null distributions are established for fixed dimensions. Furthermore those tests typically lose power when the dimension of time series is relatively large in relation to the sample size. In this talk we introduce two new omnibus tests for high-dimensional time series.

The first method uses the maximum absolute autocorrelations and cross-correlations of the component series as the testing statistic. Based on an approximation by the L-infinity norm of a normal random vector, the critical value of the test can be evaluated by bootstrapping from a multivariate normal distribution. In contrast to the conventional white noise test, the new method is proved to be valid for testing departure from white noise that is not independent and identically distributed.

The second test statistic is defined as the sum of squared singular values of the first q lagged sample autocovariance matrices. Therefore it encapsulates all the serial correlations (upto the time lag q) within and across all component series. Using the tools from random matrix theory, we derive the normal limiting distributions when both the dimension and the sample size diverge to infinity.

Joint work with Jinyuan Chang, Clifford Lam, Zeng Li, Jeff Yao and Wen Zhou.

Posters

Abdulkahar Mohamed Alkadour, Ulm University, Germany

Periodic stationary Ornstein-Uhlenbeck processes

Abstract:
In this poster, we introduce the class of periodic Ornstein-Uhlenbeck processes driven by Lévy processes. Necessary and sufficient conditions for the existence of a strictly/ weakly stationary solution of a periodic Ornstein-Uhlenbeck equation driven by a non-zero two sided Lévy process are determined.

This poster is based on joint work with Alexander Lindner.

References:

[1] Pedersen, J. (2002). Periodic Ornstein-Uhlenbeck processes driven by Lévy processes. *J. Appl. Prob.* **39**, 748–763.

[2] Brockwell, P.J. and Lindner, A. (2009). Existence and uniqueness of stationary Lévy-driven CARMA processes. *Stoch. Proc. Appl.* **119**, 2660– 2681.

[3] Brockell, P.J. und Lindner, A. (2012). Ornstein-Uhlenbeck related models driven by Lévy processes. *Statistical Methods for Stochastic Differential Equations. Chapman Hall / CRC Press*, 383–427.

David Berger, Ulm University, Germany

Some results on moving average random fields, especially CARMA random fields

Abstract:
Peter Brockwell and Yasamusa Matsuda have introduced the concept of CARMA random fields $(X_t)_{t\in\mathbb{R}^d}$ with $d \geq 1$ in [2]. They proved an easy-to-calculate formula of the autocovariance of $(X_t)_{t\in\mathbb{R}^d}$ and shown that these models are suitable for kriging of landprices in Tokyo. We prove some results of existence of these random fields and show that central

limit theorems hold for the sample mean and autocovariance. Furthermore, we give an estimator for the parameter of a CAR(1)-random field with mean $\mu \neq 0$ and show its strong consistency and asymptotic normality.

References:

[1] Berger, D. (2017). Some results on moving average random fields, especially CARMA random fields. *working paper*.

[2] Brockwell, P.J. and Matsuda, Y. (2017). CARMA Random Fields on $\mathbb{R}^d$. *J. R. Statist. Soc. B* **79**, 833–857.

[3] Cohen, S. and Lindner, A (2013). A central limit theorem for the sample autocorrelations of a Lévy driven continuous time moving average process. *Journal of Statistical Planning and Inference* **143**, 1295–1306.

[4] Lindenstrauss, E. (2001). Pointwise Theorems for Amenable Groups.*Invent. math.* **146**, 259–295.

[5] Passeggeri, R. and Veraart, A.E.D. (2017). Mixing properties of multivariate infinitely divisible random fields. *arxiv: 1704.02503v1*.

[6] Rajput, B.S. and Rosinski, J. (1989). Spectral Representations of Infinitely Divisible Processes. *Probab. Th. Rel. Fields* **82**, 451–487.

Viet Son Pham, TU Munich, Germany

Lévy-driven CARMA-type processes on the plane

Abstract:
We introduce CARMA-type processes on the plane extending the class of CARMA processes in time. This is accomplished by using a multi-parameter state-space representation driven by a Lévy basis. We characterize the existence of the process and examine some of its features including the second-order structure and path properties. In particular, we investigate the sampling behaviour and formulate conditions for the model to be a spatial ARMA process when sampled on an equidistant lattice. Although we work only on $\mathbb{R}^2$, all results can be generalized to $\mathbb{R}^d$ in a straight-forward manner.

References:

[1] Brockwell, P.J. and Matsuda, Y. (2017) Continuous autoregressive moving average random fields on $\mathbb{R}^n$. *J. R. Stat. Soc. Ser. B Stat. Methodol.* **79**, 833–857.

[2] Pham, V.S. and Chong, C. (2016) Volterra-type Ornstein-Uhlenbeck processes in space and time. *Submitted.*

Helmut Pitters, TU Dresden, Germany

PREFERENTIAL ATTACHMENT AND THE ARCSINCE COALESCENT

Abstract
We consider linear preferential attachment trees which are specific scale-free trees also known as (random) plane-oriented recursive trees. Starting with a linear preferential attachment tree of size n we show that repeatedly applying a so-called lifting yields a continuous-time Markov chain on linear preferential attachment trees. Each such tree induces a partition of $[n] = \{1, \ldots, n\}$ by placing labels in the same block if and only if they are attached to the same node in the tree. Our main result is that this Markov chain on linear preferential attachment trees induces a partition valued process which is equal in distribution (up to a random time-change) to the arcsine n-coalescent, that is the restriction to $[n]$ of the multiple merger coalescent whose Λ measure is the arcsine distribution.

References:

[1] Pitters, H. H. (2015) Linear preferential attachment trees and the arcsine coalescent, *preprint*.

[2] Pitters, H. H. (2015) Preferential attachment trees, m-ary trees, and beta coalescents,*preprint*.

Thiago do Rêgo Sousa, TU Munich, Germany

Estimation of the COGARCH process via an auxiliary AR representation for the squared returns

Abstract:
The COGARCH process was introduced in [1] and is a continuous time analog of the discrete time GARCH process. It satisfies many stylized features of financial time series and, as a continuous time model, is suited for modeling high-frequency data. We estimate the structural parameter $\boldsymbol{\theta}$ of the COGARCH process using an auxiliary model, whose instrumental parameter $\boldsymbol{\pi_\theta}$ is connected to the structural parameter $\boldsymbol{\theta}$ via an injective map. The auxiliary model is found by using projections for the squared COGARCH returns and choosing an AR model of appropriate order. The instrumental parameter $\boldsymbol{\pi_\theta}$ of the auxiliary model can be computed explicitly in terms of $\boldsymbol{\theta}$, but it is also possible to apply this method in other settings when no explicity expressions for $\boldsymbol{\pi_\theta}$ is available, provided that $\boldsymbol{\pi_\theta}$ can be approximated by simulations (see [2]). In both situations, the asymptotic theory relies on verifying the conditions for the application of a uniform law of large numbers (LLN). These conditions depend on the continuity and differentiability of the map $P_t(\cdot) : \Theta \mapsto \mathbb{R}$, where $P_t(\boldsymbol{\theta}) = \int_0^t \sigma_s(\boldsymbol{\theta}) \mathrm{d}L_s$ and $(\sigma_s(\boldsymbol{\theta}))_{s\geq 0}$ is the COGARCH volatility process. We accomplish this by using Kolmogorov's continuity criterion and prove consistency and asymptotic normality under certain moments of the driving Lévy process.

This poster is based on joint work with C. Klüppelberg and S. Haug

References:

[1] Klüppelberg, C., Lindner, A and Maller R. A. (2004) A continuous-time GARCH process driven by a Lévy process: stationarity and second-order behaviour. *Journal of Applied Probability* **41(3)**, 601–622.

[2] Sørensen, M. (2000). Prediction-based estimating functions. *The Econometrics Journal* **3(2)**, 123–147.

Johanna Vestweber, Ulm University, Germany

Geometric Ergodicity of the Multivariate Continuous-time GARCH(1,1) Process

Abstract:
For the multivariate COGARCH(1,1) volatility process we show sufficient conditions for the existence of a unique stationary distribution, for the geometric ergodicity and for the finiteness of moments of the stationary distribution. One of the conditions demands a sufficiently fast exponential decay of the MUCOGARCH(1,1) volatility process. Furthermore, we show easily applicable sufficient conditions for the needed irreducibility of the volatility process living in the cone of positive semidefinite matrices, if the driving Lévy process is a compound Poisson process.

This poster is based on a joint work with Robert Stelzer.

References:

[1] Stelzer, R. (2010) Multivariate COGARCH(1,1) Processes. *Bernoulli* **16**, 80– 115.

[2] Stelzer, R., and Vestweber, J. (2017) Exponential Ergodicity of Multivariate COGARCH(1,1) Processes, `arXivpreprintarXiv:1701.07859`, *Submitted*.

Philip Weißmann, University of Mannheim, Germany

Lévy processes conditioned to avoid an interval

Abstract:
We consider an oscillating Lévy process ξ such that the ascending and descending ladder height processes have finite means and some other mild technical assumptions are satisfied. The aim is to construct the process ξ to avoid an interval $[a, b]$ in a meaningful way, although

$$T_{[a,b]} := \inf\{t \geq 0 : \xi_t \in [a, b]\} < +\infty$$

almost surely. The strategy is like in several examples of conditioned Lévy processes, like the process conditioned to stay positive (Silverstein [3], Chaumont and Doney [1]) or the process conditioned to avoid zero (Panti [2]). Namely we want to find a harmonic function

h for the process killed on entering $[a, b]$ and to show that the corresponding h-transform equals

$$\mathbb{P}_x^{\updownarrow}(\Lambda) := \lim_{q \searrow 0} \mathbb{P}_x(\Lambda, t < e_q | e_q < T_{a,b})$$

for a $\mathcal{F}_t$-measurable set Λ. The idea of how this harmonic function looks is based on stochastic potential theory. But it turns out that this function is the analogue to the harmonic function Vysotsky [4] found for a random walk killed on entering a bounded interval.

This poster is based on joint work with Leif Döring and Alexander Watson.

References:

[1] Chaumont, L. and Doney, R.A. (2005) On Lévy processes conditioned to stay positive. *Electron. J. Probab.* **10**, 948–961

[2] Panti, H. (2016) On Lévy processes conditioned avoid zero. *ArXiv 1304. 3191v3*

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[4] Vysotsky, V. (2015) Limit theorems for random walks that avoid bounded sets, with applications to the largest gap problem. *Stoch. Process. Appl.* **125**, 1886–1910.

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