30th Conference on

**Stochastic Processes and their Applications**

University of California
Santa Barbara, California, USA
June 26 - July 1, 2005

Organized under the auspices of the
Bernoulli Society for Mathematical Statistics and Probability
Co-sponsored by the Institute of Mathematical Statistics

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Bernoulli Society for Mathematical Statistics and Probability
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The USA Army Research Office
Elsevier Publishing Company
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Special thanks to

UCSB Conference Center, in particular
Sally Vito, Miki Swick, Joe Allegretti
Claudia Carlson and Mrs. Denna Zamarron
(administrative assistance)
Hoon Rhew and Eduardo Montoya
(technical assistance)
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# The Week at a Glance

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<tr>
<td>8:30~8:45</td>
<td>Opening Remarks</td>
<td>Invited Talk</td>
<td>Invited Talk</td>
<td>Invited Talk</td>
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<tr>
<td>8:45~9:45</td>
<td>Deift</td>
<td>Tóth</td>
<td>Englander</td>
<td>Duffie</td>
<td>Landim</td>
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<td>Yoshida</td>
<td>Mytnik</td>
<td>Taylor</td>
<td>Glynn</td>
<td>Gantert</td>
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<td>10:45~11:00</td>
<td>Refreshments</td>
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<td>11:00~12:00</td>
<td>Invited Talk</td>
<td>Lévy Lecture</td>
<td>IMS Medallion Lecture</td>
<td>Invited Talk</td>
<td>IMS Medallion Lecture</td>
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<td></td>
<td>Warnow</td>
<td>Bertoin</td>
<td>Sznitman</td>
<td>Limic</td>
<td>LeGall</td>
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<td>12:00~2:00</td>
<td>Lunch Break</td>
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<td>2:00~3:35</td>
<td>Contributed talks</td>
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<td>3:35~3:50</td>
<td>Refreshments</td>
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<tr>
<td>3:50~5:25</td>
<td>Contributed Talks</td>
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<td></td>
<td>Shuttle service to downtown 6:30~10:30pm</td>
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<td>Location:</td>
<td>In UCen building</td>
<td>Invited talks: Corwin West</td>
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<td>Sessions A1-6: Corwin East</td>
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<td>Sessions B1-6: State Street</td>
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<td>Sessions C1-6: Harbor</td>
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<td>Sessions D1-6: Corwin West</td>
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## Invited Speaker Schedule

All Invited talks take place at Corwin West, UCen building

### Monday, June 27

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>8:45~9:45</td>
<td>Percy Deift</td>
<td>Universality for mathematical and physical systems</td>
</tr>
<tr>
<td>9:45~10:45</td>
<td>Nobuo Yoshida</td>
<td>Large time behavior of directed polymers in random environment</td>
</tr>
<tr>
<td>10:45~11:00</td>
<td></td>
<td>Refreshments</td>
</tr>
<tr>
<td>11:00~12:00</td>
<td>Tandy Warnow</td>
<td>The disk-covering method for phylogenetic tree reconstruction</td>
</tr>
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</table>

### Tuesday, June 28

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>8:45~9:45</td>
<td>Bálint Tóth</td>
<td>Hyperbolic hydrodynamic limits for systems with two conservation laws</td>
</tr>
<tr>
<td>9:45~10:45</td>
<td>Leonid Mytnik</td>
<td>On uniqueness for stochastic heat equations with non-Lipschitz coefficients</td>
</tr>
<tr>
<td>10:45~11:00</td>
<td></td>
<td>Refreshments</td>
</tr>
<tr>
<td>11:00~12:00</td>
<td>Jean Bertoin</td>
<td>Different aspects of model for random fragmentation processes</td>
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</table>

### Wednesday, June 29

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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<tbody>
<tr>
<td>8:45~9:45</td>
<td>Janos Englander</td>
<td>Spatial branching in random media</td>
</tr>
<tr>
<td>9:45~10:45</td>
<td>Jonathan Taylor</td>
<td>Critical values of smooth random fields</td>
</tr>
<tr>
<td>10:45~11:00</td>
<td></td>
<td>Refreshments</td>
</tr>
<tr>
<td>11:00~12:00</td>
<td>Alain-Sol Sznitman</td>
<td>Random motions in random media</td>
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### Thursday, June 30

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>8:45~9:45</td>
<td>Darrell Duffie</td>
<td>Term structure of conditional probabilities of corporate default</td>
</tr>
<tr>
<td>9:45~10:45</td>
<td>Peter Glynn</td>
<td>Traffic modeling for queues</td>
</tr>
<tr>
<td>10:45~11:00</td>
<td></td>
<td>Refreshments</td>
</tr>
<tr>
<td>11:00~12:00</td>
<td>Vlada Limic</td>
<td>Natural questions and fewer answers on reinforced walks</td>
</tr>
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</table>

### Friday, July 1

<table>
<thead>
<tr>
<th>Time</th>
<th>Speaker</th>
<th>Topic</th>
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</thead>
<tbody>
<tr>
<td>8:45~9:45</td>
<td>Claudio Landim</td>
<td>Macroscopic current fluctuations in stochastic lattice gases</td>
</tr>
<tr>
<td>9:45~10:45</td>
<td>Nina Gantert</td>
<td>Random walk in random scenery</td>
</tr>
<tr>
<td>10:45~11:00</td>
<td></td>
<td>Refreshments</td>
</tr>
<tr>
<td>11:00~12:00</td>
<td>Jean-François LeGall</td>
<td>Conditioned Brownian trees</td>
</tr>
<tr>
<td>A1</td>
<td>A2</td>
<td>A3</td>
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<tr>
<td>Branching Processes</td>
<td>Stochastic Analysis I</td>
<td>Interacting Particle Systems</td>
</tr>
<tr>
<td>B1</td>
<td>B2</td>
<td>B3</td>
</tr>
<tr>
<td>Stochastic Modeling in Physics and Biology I</td>
<td>Stochastic Modeling in Physics and Biology II</td>
<td>Information and Related Topics</td>
</tr>
<tr>
<td>C1</td>
<td>C2</td>
<td>C3</td>
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<tr>
<td>Random Matrices and Related Processes</td>
<td>Run and Gambling</td>
<td>Long-range Dependence and Heavy-Tails</td>
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<tr>
<td>D1</td>
<td>D2</td>
<td>D3</td>
</tr>
<tr>
<td>Mathematical Finance I</td>
<td>Stochastic Control</td>
<td>Mathematical Finance II</td>
</tr>
</tbody>
</table>

**Overview of Contributed Paper Sessions**

**Monday, June 27**

- A1 - Branching Processes
- B1 - Stochastic Modeling in Physics and Biology I
- C1 - Random Matrices and Related Processes
- D1 - Mathematical Finance I

**Tuesday, June 28**

- A2 - Stochastic Analysis I
- B2 - Stochastic Modeling in Physics and Biology II
- C2 - Run and Gambling
- D2 - Stochastic Control

**Thursday, June 30**

- A3 - Interacting Particle Systems
- B3 - Information and Related Topics
- C3 - Long-range Dependence and Heavy-Tails
- D3 - Mathematical Finance II

- A4 - Stochastic Analysis II
- B4 - Time Series
- C4 - Limit Theorems
- D4 - Mathematical Finance III

- A5 - Stochastic Analysis III
- B5 - Stochastic Networks
- C5 - Extremes/Path Properties
- D5 - Risk Theory

- A6 - Stochastic Integrals
- B6 - Filtering and Estimation
- C6 - Stochastic Partial Differential Equations
- D6 - Mathematical Finance IV
<table>
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<tr>
<th>Time</th>
<th>A Corwin East</th>
<th>B State Street</th>
<th>C Harbor</th>
<th>D Corwin West</th>
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</thead>
</table>
|           | A1 - Branching Processes  
*Chaired by J.F. LeGall* | B1 - Stochastic Modeling in Physics and Biology I  
*Chaired by S. Kou* | C1 - Random Matrices and Related Processes  
*Chaired by P. Deift* | D1 - Mathematical Finance I  
*Chaired by J. Vecer* |
| 2:00~2:20 | Aldous  
*A critical branching process model for biodiversity* | Ozbek  
*Decomposition of motor unit firing pattern with Kalman filtering* | El-Karoui  
*Recent results about the largest eigenvalue of large random covariance matrices and statistical applications* | Lee  
*Insider's hedging in jump diffusion model* |
| 2:25~2:45 | Harris J.  
*Branching Brownian motion with absorption* | Papavasiliou  
*Simulating multiscale systems* | Kawczak  
*On spectrum of the covariance operator for nilpotent Markov chain* | Lim  
*Pricing derivative securities in incomplete markets: a simple approach* |
| 2:50~3:10 | Harris S.  
*Application of 'spines' in branching diffusions* | Piryatinska  
*Estimations of the parameters of the smoothly truncated Lévy distributions and their applications to EEG-sleep patterns of neonates* | Liao  
*Simultaneous bootstrap confidence region for covariance matrix* | Zitkovic  
*Financial equilibria in the semimartingale setting; complete markets and markets with withdrawal constraints* |
| 3:15~3:35 | Yanev  
*Number of infinite N-ary subtrees on Galton-Watson trees* | Shcherbakov  
*Cooperative sequential absorption and related sequential Markov point processes* | Rider  
*Gaussian fluctuations for non-Hermitian random matrix ensembles* | Zhang  
*Continuous-time principal-agent problems with hidden actions* |
| 3:35~3:50 | Refreshments |
| 3:50~4:10 | A2 - Stochastic Analysis I  
*Chaired by H. Kaspi* | B2 - Stochastic Modeling in Physics and Biology II  
*Chaired by T. Warnow* | C2 - Ruin and Gambling  
*Chaired by A. Puha* | D2 - Stochastic Control  
*Chaired by D. Ocone* |
| 4:15~4:35 | Zhou  
*Exit problems for reflected spectrally negative Lévy processes* | Atzberger  
*A stochastic immersed boundary method for microscale biological fluid dynamics* | Allaart  
*Prophet regions for uniformly bounded random variables with random discounting* | Hadjiliadis  
*Change-point detection in the Brownian motion model with two-sided alternatives* |
| 4:40~5:00 | Salminen  
*Integral functionals, occupation times and hitting times of diffusions* | Kou  
*Stochastic modeling in single molecule biophysics* | Krink  
*Gambler's ruin with catastrophes* | Weerasinghe  
*A bounded variation control problem for diffusion processes* |
| 5:00~5:25 | Ryznar  
*Hitting distributions of geometric Brownian motion* | Yang  
*Canonical forms for identifying aggregated Markov models of single ion channel gating kinetics* | Schweinsberg  
*Improving on bold play when the gambler is restricted* | Yao  
*Corrected random walk approximations to free boundary problems in optimal stopping* |
|           | Bojchuk  
*On boundary functionals connected with crossing of the level by Lévy process* | Nacu  
*Ant networks* | Lu  
*Finite horizon ruin probability computation for heavy tailed distributions through corrected diffusion approximation* | Zamfirescu  
*Martingale approach to stochastic control with discretionary stopping* |
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<tr>
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<th>A Corwin East</th>
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<th>C Harbor</th>
<th>D Corwin West</th>
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</table>
| 2:00~2:20  | A3 - Interacting Particle Systems  
               Chaired by A.S. Sznitman | B3 - Information and Related Topics  
               Chaired by A. Carter | C3 - Long-range Dependence and Heavy-Tails  
               Chaired by M. Ryznar | D3 - Mathematical Finance II  
               Chaired by J. Zhang |
| Assing     | Debowksi      | Didier         | Figueuroa-Lopez |
| 2:25~2:45  | Kordzakhia    | Kozubowski     | Ludkovski   |
| 2:50~3:10  | Loebus        | Jain           | Meng        |
| Rassoul-Agha |             | Podgorski      | Palczewski  |
| 3:15~3:35  | The random average process and random walk in a space-time random environment in one dimension |
| Rezaeian   | The entropy rate of the hidden Markov process |
| Zanten     | Representations of fractional Brownian motion using vibrating strings |
| Palczewski | Impulsive control of portfolios |
| Refreshments | A4 - Stochastic Analysis II  
              Chaired by B. Rider | B4 - Time Series  
              Chaired by K. Podgorski | C4 - Limit Theorems  
              Chaired by J. Yukich | D4 - Mathematical Finance III  
              Chaired by G. Zitkovic |
<p>| 3:50<del>4:10  | Delmas        | Di Lascio      | Beutner     |
| Erlihsion  | Nonlinear ARMA doubly stochastic and state dependent models: a new general approach to nonlinear time series analysis |
| Helan      | Forecasting performance of asymmetric GARCH models |
| Balan      | A strong invariance principle for associated random fields |
| 4:15</del>4:35  | Strum         | Torrisi        | Beishwal    |
| 4:40<del>5:00  | A super-stable motion with infinite mean branching |
| 5:05</del>5:25  | Swanson       | Carter         | Vecer       |</p>
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<th>C Harbor</th>
<th>D Corwin West</th>
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</table>
| 2:00~2:20  | A5 - Stochastic Analysis III  
  *Chaired by G. O'Brien* | B5 - Stochastic Networks  
  *Chaired by P. Glynn* | C5 - Extremes/Path Properties  
  *Chaired by R. Bradley* | D5 - Risk Theory  
  *Chaired by M. Tehranchi* |
|            | Cox           | Ghosh                   | Herbin                    | Blanchet                               |
|            | Skorokhod embeddings with  
  Chacon-Walsh style constructions | Optimal controls for stochastic networks in heavy traffic | Hölder regularity for a set-indexed fractional Brownian motion | Approximations for the distribution of infinite horizon discounted rewards |
| 2:25~2:45  | Kaspi         | Kang                    | Nardi                     | Molina                                 |
|            | A characterization of the infinitely divisible squared Gaussian processes | An invariance principle for semimartingale reflecting Brownian motions (SRBMs) in domains with piecewise smooth boundaries | On the distribution of the maximum of a smooth Gaussian field | Risk measures for derivative securities on diffusion processes |
| 2:50~3:10  | Picard        | Puha                    | Sanz-Sole                 | Chernobai                              |
|            | About the stochastic integral representation of Wiener functionals | The fluid limit of an overloaded processor sharing queue | Small perturbations of rough paths of fractional Brownian motion | Modelling catastrophe claims with left-truncated severity distributions |
| 3:15~3:35  | Sauga         | Xia                     | Yukich                    |                                     |
|            | Anomalous mobility of Brownian particles in a tilted symmetric sawtooth potential | Poisson process approximation in Jackson networks | Central limit theorems for convex hulls and maximal points |                                     |
| 3:35~3:50  | Refreshments  |                         |                          |                                       |
| 3:50~4:10  | A6 - Stochastic Integrals  
  *Chaired by R. Feldman* | B6 - Filtering and Estimation  
  *Chaired by J. Schweinsberg* | C6 - Stochastic Partial Differential Equations  
  *Chaired by M. Chaleyat-Maurel* | D6 - Mathematical Finance IV  
  *Chaired by D. Duffie* |
| 4:15~4:35  | Hult          | Bhattacharya             | Bonnet                    | Rossi                                  |
|            | Extremal behavior of stochastic integrals driven by regularly varying Lévy processes | Weighted conditional least squares estimation and its asymptotic properties for controlled branching processes | On some nonlinear SPDE's, from branching particle systems to fluid dynamics | Contingent claims valuation in a class of nonnormal autoregressive multifactor forward rate models |
| 4:40~5:00  | Tin-Lam       | Chigarsky                | Gawatecki                 | Durrleman                              |
|            | The Henstock approach to multiple stochastic integrals | What is always stable in nonlinear filtering? | A relationship between finite and infinite dimensional stochastic differential equations | From implied to spot volatilities |
|            | Bishwal       | Koniecny                 | Lototsky                  | Tehranchi                              |
|            | Stochastic integration and truncated Hausdorff moment problem | Optimal nonlinear and linear filtering of Poisson cluster processes | SPDEs, Wiener chaos, and turbulent transport | The term structure approach to implied volatility |
Abstracts of invited and contributed talks are listed in alphabetical order under the family name of the author.

An index for all speakers can be found on page 115.
Motivated as a null model for comparison with data, we study the following model for a phylogenetic tree on $n$ extant species. The origin of the clade is a random time in the past, whose (improper) distribution is uniform on $(0, \infty)$. After that origin, the process of extinctions and speciations is a continuous-time critical branching process of constant rate, conditioned on having the prescribed number $n$ of species at the present time. We study various mathematical properties of this model as $n \to \infty$ limits: time of origin and of most recent common ancestor; pattern of divergence times within lineage trees; time series of numbers of species; number of extinct species in total, or ancestral to extant species; and “local” structure of the tree itself. We emphasize several mathematical techniques: associating walks with trees, a point process representation of lineage trees, and Brownian limits. Preprint available at math.PR/0410402.
Prophet regions for uniformly bounded random variables with random discounting

Pieter Allaart (speaker)

Mathematics Department, University of North Texas, P.O. Box 311430, Denton, TX 76203-1430, USA allaart@unt.edu

A prophet region is a set of all possible ordered pairs \((x, y)\) such that \(x\) is the optimal stopping value, and \(y\) is the expected maximum of a sequence \((Y_1, \ldots, Y_n)\) of random variables belonging to a specific class. The name “prophet region” derives from the fact that the expected maximum of a sequence can be thought of as the maximum expected reward of a player with complete foresight, or “prophet”. A classical result due to Hill [4] says that for the class of sequences of independent, \([0, 1]\)-valued random variables \(Y_1, \ldots, Y_n\), the prophet region is exactly the set \(\{(x, y) : 0 \leq x \leq 1, x \leq y \leq 2x - x^2\}\). This result has been generalized in many different directions. (See the survey paper [5].) Particularly, Boshuizen [3] gave a prophet region for the case \(Y_j = \beta^{j-1}X_j\), where \(X_1, \ldots, X_n\) are independent \([0, 1]\)-valued, and \(\beta \in (0, 1)\) is a discount factor.

We extend Boshuizen’s result to the case where the discount factors themselves are random. Specifically, let \(X_1, \ldots, X_n\) be \([0, 1]\)-valued random variables, and let \(B_1, \ldots, B_{n-1}\) be independent \([0, 1]\)-valued random variables which are further independent of the \(X_j\)’s, and such that \(EB_j = \beta > 0\) for all \(j\). Let \(Y_j = B_1 \cdots B_{j-1}X_j\) for \(j = 1, \ldots, n\). Prophet regions for the sequence \(Y_1, \ldots, Y_n\) will be given in two cases: (i) when \(X_1, \ldots, X_n\) are independent [1], and (ii) when \(X_1, \ldots, X_n\) are arbitrarily dependent [2]. These prophet regions yield several sharp prophet inequalities.

The Behavior of the Critical Second Order Field in the Symmetric Simple Exclusion Regime

SIGURD ASSING (speaker)

Dept. of Statistics, University of Warwick, Coventry CV4 7AL, UK
[s.assing@warwick.ac.uk]

We study simple exclusion processes in infinite volume. For space dimensions $d \geq 3$ it has recently been shown (see [2],[3]) that even in the asymmetric case the density fluctuations around a steady state of the hydrodynamic limit can be approximated by a stationary generalized Ornstein-Uhlenbeck process.

The proof's crucial point can be described by the fact that the space-time fluctuations of the current (a second order field) are projected down onto a deterministic time independent linear transformation of the gradient of the density fluctuation field. This linear transformation is determined by the so-called diffusion coefficient $D(\alpha) = \{D_{i,j}(\alpha)\}_{1 \leq i,j \leq d}$ where the parameter $\alpha$ indicates the chosen equilibrium measure.

However in dimensions $d = 1,2$ a diffusion coefficient does not exist, it diverges (cf. [4]). So what happens to the corresponding current fluctuations? They diverge because the asymmetry is too strong. How can we weaken the asymmetry so that the current fluctuations still converge and what is the critical level of “weak” asymmetry?

We answer these questions in dimension $d = 1$. It turns out that the critical level of “weak” asymmetry is not determined by the rate of divergence of the diffusion coefficient approximation, it is rather determined by the behavior of the current fluctuations’ analogon in the symmetric exclusion regime. The latter is not very surprising because all proofs in [2],[3],[4] were finally based on estimations on the symmetric part of the dynamics.

But it was surprising that the Boltzmann-Gibbs principle breaks down for this second order field of interest in the symmetric exclusion regime. Its scaling limit converges to a quadratic functional of the linear density fluctuation field which was already described in [1].

A Stochastic Immersed Boundary Method for Microscale Biological Fluid Dynamics

Paul J. Atzberger (speaker)

Department of Mathematics, Rensselaer Polytechnic Institute, 308 Amos Eaton Hall, Troy, NY 12180, USA [atzberg@rpi.edu]

Peter R. Kramer

Rensselaer Polytechnic Institute, USA [kramep@rpi.edu]

The immersed boundary method [1] has found wide use in many biological applications as an efficient numerical method to simulate fluid which interacts with immersed elastic structures. Advances in cell and molecular biology have led to an increasing interest in modeling microscale systems at a coarse level where methods such as molecular dynamics become infeasible as a consequence of the wide range of active length and time scales. At such scales one approach is to model using a continuum description, however, physical matter is discrete and at small scales thermal fluctuations become an important feature of many biological systems. In this talk we discuss a stochastic immersed boundary method which incorporates thermal fluctuations and present a numerical method. The analysis of the convergence of the method and of the invariant measures presents a variety of challenges since the associated Fokker-Planck equations are not elliptic. We show that these equations are what is termed “hypoelliptic” and present rigorous results on convergence of the method and on the existence and uniqueness of the invariant measure. We further discuss the physicality of the method with respect to equilibrium statistical mechanics and with respect to the nonequilibrium dynamics of diffusing particles and polymers. In conclusion, we present numerical results that demonstrate how the method can be used to explore the statistical mechanics of polymer knots and membranes.

A strong invariance principle for associated random fields

RALUCA BALAN(speaker)

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In this paper we generalize Yu’s strong invariance principle [4] for associated sequences to the multi-parameter case, under the assumption that the covariance coefficient $u(n)$ decays exponentially as $n \to \infty$. The main tools that we use are: the multi-parameter blocking technique introduced in [1], the quantile transform method (originally developed in [3]) and the Berry-Esseen theorem of [2].

Different Aspects of a Model for Random Fragmentation Processes

JEAN BERTOIN (speaker)

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Fragmentation is natural phenomenon that can be observed at a great variety of scales. To give just a few examples, we may think of stellar fragments and meteoroids in Astrophysics, fractures and earthquakes in Geophysics, crushing in the mining industry, breaking of crystals in Crystallography, degradation of large polymer chains in Chemistry, fission of atoms in Nuclear Physics, fragmentation of a hard drive or files in Computer Science, ... In this talk, we will be interested in situations where this phenomenon occurs randomly and repeatedly as time passes. Typically, we may imagine the evolution of blocks of mineral in a crusher.

We will consider a stochastic model for fragmentation processes which is meant to describe the evolution of an object that falls apart randomly as time passes. The model is characterized by a few parameters, namely the index of self-similarity, the rate of erosion and the dislocation measure. We shall survey several of its probabilistic aspects (branching random walks, multiplicative cascades, exchangeable random partitions, ...) Each point of view yields useful techniques to establish properties of such random fragmentation processes, which depend crucially on the parameters.

An extended version of the talk is presented in [1].

On the Mean-Variance Hedging Problem under Transaction Costs and the "No-free-lunch in $L^2$ condition"

ERIC BEUTNER (speaker)

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The paper proposes a new approach to the mean-variance hedging problem under proportional transaction costs in a multiperiod model. The problem will be studied in a general incomplete multidimensional market. Some technical assumptions such as the RAS condition are excluded.

First, we introduce the model and formulate the mean-variance hedging problem under proportional transaction costs. Let $P$ denote the set of all random variables which are attainable if the investor is only allowed to buy shares of stock $i$, $1 \leq i \leq d$ (pure buying strategy) and let $S$ denote the set of all random variables which are attainable if the investor is only allowed to sell shares of stock $i$, $1 \leq i \leq d$ (pure selling strategy). Clearly, the sum of $P$ and $S$ is the gain functional under proportional transaction costs.

We use some well-known conditions on the price process and weak convergence to show that $P$ is a closed convex cone in $L^2$. The same conditions allow us to show that $S$ is a closed convex cone in $L^2$. In order to prove that there exists a unique solution to the mean-variance hedging problem under proportional transaction costs we have to show that the sum of $P$ and $S$ is a closed convex subset of $L^2$. This leads to the question under which condition the sum of two closed convex cones of a Hilbert space is closed.

We establish a sufficient condition for the sum of two closed convex cones of a Hilbert space to be closed. To apply this condition to our problem we introduce the "No-free-lunch in $L^2$ condition". Under the "No-free-lunch in $L^2$ condition" the sum of $P$ and $S$ is a closed convex subset of $L^2$ which implies that there exists a unique solution to the mean-variance hedging problem under proportional transaction costs. Furthermore, we give some applications of our result.

Weighted Conditional Least Squares Estimation and its Asymptotic Properties for Controlled Branching Processes

Archan Bhattacharya (speaker)

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The subject of branching processes has always provided a useful way to model population evolution and dynamics. Many modifications of standard Galton-Watson branching process have been proposed in the literature. Here, we consider situations in the study of population dynamics where some control on the growth of the population is necessary. In these instances, a class of models known as controlled branching processes, where the number of individuals with reproductive capacity is controlled by a function, has been found to be useful. The talk is concerned with estimation of parameters in a controlled branching process using weighted conditional least squares approach. The asymptotic properties of the above estimator are investigated in subcritical, critical and supercritical cases. Also a unified distribution theory of the estimator in different cases is proposed.

The Value of Waiting to Invest Under Persistent Shocks

JAYA BISHWAL (speaker)

University of California, Santa Barbara

CHRISTOPHER HENNESSY

University of California, Berkeley

The real options approach to corporate investment decision making recognizes a firm can delay an investment decision and wait for more information concerning project cashflows. The classic model of McDonald and Siegel (1986) and Dixit and Pindyck (1994) value the investment decision as a perpetual American option and in doing so, essentially assumes the real asset underlying the option is traded, or that there is a perfect spanning asset available. Most real projects have persistent shocks. We assume a model driven by persistent fractional Brownian motion and we adopt the Wick-Itô calculus. The classic model follows from our model as a special case. In this model, we obtain in closed form the value of the option to invest and the optimal investment trigger level, above which investment takes place. Interalia we prove the fractional Dynkin’s formula which is of independent interest, which plays an important role in stochastic control problems. Using this as a tool, we verify the Kolmogorov’s smooth pasting condition to obtain our main result.

To find the value function for the installed project, we use a standard dynamic delta hedging argument to construct a riskless portfolio consisting of a long position in the project and a short position in the underlying commodity, with the counterparty taking the long position in the underlying commodity requiring payment of the convenience yield.

We solve for the value of the perpetual call option on the installed project in two steps. First, for any finite expiry date we derive an approximate solution. To obtain an exact solution for the price of the perpetual call we let the expiry date go to infinity.

For each point in time we solve the optimal time-dependent exercise threshold utilizing the smooth pasting condition.

As the classic model recommends the firm always postpones investment, our model recommends the firm to postpone investment. By delaying investment, the firm trades off a higher present value of the investment cost when shocks are persistent.
Stochastic Integration and Truncated Hausdorff Moment Problem

JAYA BISHWAL (speaker)

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I introduce a new stochastic integral and show its relation to the truncated Hausdorff moment problem. I study the applications of the new integral to higher order approximate maximum likelihood estimation in diffusion processes and higher order discrete time delta hedging of European vanilla options in a generalized Black-Scholes market.

Let \( \{W_t, t \geq 0\} \) be a standard Brownian motion on the stochastic basis \((\Omega, \mathcal{F}, \{\mathcal{F}_t\}_{t \geq 0}, Q)\). Consider the Itô SDE

\[
dX_t = a(t, X_t) \, dt + b(t, X_t) \, dW_t, \quad t \in [0, T].
\]

Consider a partition \( \Pi_n := \{0 = t_0 < t_1 < \ldots < t_n = T\} \) with \( \Delta_n \to 0 \) as \( n \to \infty \) where \( \Delta_n := \max_{1 \leq i \leq n} (t_i - t_{i-1}) \). For a smooth function \( f \), the new integral is defined as

\[
B_T := \int_0^T f(t, X_t) \, dW_t
\]

\[
= \operatorname{lim}_{n \to \infty} \sum_{i=1}^n \sum_{j=1}^m p_j f \left( (1-s_j) t_{i-1} + s_j t_i, (1-s_j) X_{t_{i-1}} + s_j X_{t_i} \right) \Delta W_{t_i}
\]

where \( \Delta W_{t_i} := W_{t_i} - W_{t_{i-1}}, \quad i = 1, 2, \ldots, n \), and \( p_j, \quad j \in \{1, 2, \ldots, m\} \) is a probability mass function of a discrete random variable \( S \) on \( 0 \leq s_1 < s_2 < \cdots < s_m \leq 1 \) with \( P(S = s_j) = p_j, \quad j \in \{1, 2, \ldots, m\} \). Denote the \( k \)-th moment of the random variable \( S \) as \( \mu_k := \sum_{j=1}^m s_j^k p_j, \quad k = 1, 2, \cdots \). The new integral and the Itô integral are connected as follows:

\[
B_T = I_T + \mu_1 \int_0^T f(t, X_t) \, dt
\]

where \( I_T = \int_0^T f(t, X_t) \, dW_t \) is the Itô integral. When \( \mu_1 = 0 \), the new integral is the Itô integral. When \( \mu_1 = \frac{1}{2} \), the new integral is the Fisk-Stratonovich integral. The order of mean square approximation error (rate of convergence) in the new integral is \( n^{-\nu} \) where

\[
\nu := \inf \left\{ k : \mu_k \neq \frac{1}{1+k}, \mu_j = \frac{1}{1+j}, j = 0, 1, \cdots, k-1 \right\}.
\]

I construct approximation schemes with rate of convergence up to \( \nu = 6 \). In general, I look for a distribution \( P(s) \) such that

\[
\int_0^1 s^j dP(s) = \frac{1}{1+j}, \quad j = 1, 2, \cdots, n-1, \quad \int_0^1 s^n dP(s) \neq \frac{1}{1+n}.
\]
Approximations for the Distribution of Infinite Horizon Discounted Rewards

JOSE H. BLANCHET (speaker)

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PETER W. GLYNN

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For $t \geq 0$, let $\Lambda (t)$ be a real-valued random variable representing the cumulative reward associated with running a system over $[0, t]$. In the presence of a stochastic inflation rate, the infinite horizon discounted reward takes the form $D = \int_{(0, \infty)} \exp (-\Gamma (t)) d\Lambda (t)$, where $\Gamma = (\Gamma (t) : t \geq 0)$ is a real-valued process. Our focus, in this talk, is on the development of approximations for the distribution of the random variable (r.v.) $D$ (and not just its expected value) when the inflation rate corresponding to $\Gamma$ is small - a setting that arises often in applications.

The distribution of $D$ plays a key role in a number of different applications contexts. For example, in life contingencies $D$ arises in the valuation of pension funds (see [3]); in insurance risk theory with return on investments the distribution of $D$ provides the key ingredient to compute ruin probabilities (see, for example, [5]). $D$ also plays a major role in the analysis of stationary ARCH processes, which are widely used to model financial and economic time series; see, for example, [1]. Other settings in which the distribution of $D$ arises as a central object are described by [4] and include computer science (in the analysis of sorting algorithms) and analytic number theory. [2] describe several other applications arising in mathematical physics and finance.

As stated earlier, our focus is on approximations for the distribution of $D$ in a setting of “small” inflation rates. We shall discuss Laws of Large Numbers, Central Limit Theorems and large deviation principles that hold in great generality. In addition, Edgeworth expansions and precise large deviation asymptotics are also discussed when the discount and rewards are driven by Markov processes. We also explain how these results are utilized to develop efficient rare event simulation methodology for discounted processes.

Let $\xi(t)$, $t \geq 0$, $\xi(0) = 0$ be a homogeneous process with independent increments and we put $\tau(x) = \inf\{t > 0 : \xi(t) > x\}$, $\gamma^\pm(x) = \pm(\xi(\tau(x) \pm 0) - x)$.

We propose a new approach to the study of these functionals which is based on the compensation formula (see [1] or [2]). To formulate some results we put

$$F_+(y, \lambda) = \int_0^\infty e^{-\lambda t} P\{\sup_{s \leq t} \xi(s) < y\} dt, \quad y \geq 0,$$

and let $\Pi\{\cdot\}$ be Lévy measure of the process. We also put $J\{A\} = 1$ if $A$ takes place and $= 0$ otherwise.

**Theorem 1** Let $0 < m = E\xi(1) < \infty$ and $\int_1^\infty x^{1+\alpha} \Pi(dx) < \infty$, $\alpha \geq 0$. Then

$$P\{\gamma^-(x) \geq z_1, \gamma^+(x) \geq z_2\} =$$

$$= \frac{1}{m} \int_0^\infty \int_{-\infty}^{+0} \{t - y \geq z_1\} \Pi\{(z_2 + t - y, \infty)\} dP\{\inf_{s \geq 0} \xi(s) < y\} dt + o(x^{-\alpha})$$

as $x \to \infty$.

The following theorem describes the possibility that the process $\xi(t)$ reaches a level $x$ in continuous way and generalizes some results from [2].

**Theorem 2** For all $x > 0$ we have

1) $E\{e^{-\lambda \tau(x)}, \gamma^-(x) = 0\} = \lambda \beta_+(\lambda) \frac{d}{dx} F_+(x, \lambda)$,

2) if $\lim_{\epsilon \to 0}(\ln \epsilon + \epsilon t^{-1} P\{\xi(t) > \epsilon\} dt) = -\infty$, then

$$P\{\gamma^-(x) > 0, \gamma^+(x) > 0/\tau(x) < \infty\} = 1.$$

Here $\beta_+(\lambda) \geq 0$ is some constant.

On some nonlinear SPDE’s, from branching particle systems to fluid dynamics

Guillaume Bonnet (speaker)

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I will begin by reviewing some previous results on a superprocess with singular interactions whose density solves a Burgers-type (nonlinear) SPDE. I will then present some more recent results on a related KPZ-type equation and a nonlinear heat equation that related to the superprocess via a Hopf-Cole transformation. One direction of this transformation was derived in [1] for an equation with additive noise. Surprisingly, among stochastic Burgers equations with multiplicative noise, this transformation seem to be available only in the superprocess setting. I will then present some work in progress for the inviscid version of this type of nonlinear equations with colored noise.

On a stationary, triple-wise independent, absolutely regular counterexample to the central limit theorem

Richard C. Bradley (speaker)

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Janson [3] constructed several classes of (nondegenerate) strictly stationary random sequences \((X_k, k \in \mathbb{Z})\) which have finite second moments and are pairwise independent but fail to satisfy a central limit theorem. Subsequently, Bradley [1] constructed two more such examples. One has two states and is ergodic, and the other has three states and satisfies absolute regularity. Later, Pruss [4] constructed, for an arbitrary integer \(N \geq 3\), an \(N\)-tuplewise independent, identically distributed (but not strictly stationary) random sequence for which the central limit theorem fails. In that paper, he posed the question whether any such examples exist which are strictly stationary. Bradley [2] answered that question affirmatively for \(N = 3\) by showing that both examples in his earlier paper [1] satisfy triple-wise independence. For \(N \geq 4\), Pruss’ question remains unsolved; however, for \(N \geq 4\), there do not exist such (strictly stationary) counterexamples that satisfy the Rosenblatt strong mixing condition.

Approximating nonparametric regression experiments by continuous Gaussian processes when the variance is unknown.

ANDREW V CARTER (speaker)

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Brown and Low [1] showed that nonparametric regression experiments are statistically asymptotically equivalent (in the sense of Le Cam’s deficiency distance) to a Brownian motion process with an unknown drift function. Their result requires that the variance of the observations is known.

The variances of the observations in a nonparametric regression experiment are generally considered unknown nuisance parameters. Including this extra parameter in the definition of the experiment changes the form of the approximation that would be appropriate because a Brownian motion is completely informative about its variance. I show that the regression problem with an unknown mean function $f(x)$ and variance $\sigma^2$ can be approximated by the process

$$Y(t) = \int_0^t f(x) \, dx + \frac{\sqrt{n}}{V}(t)$$

where $W(t)$ is a standard Brownian motion and $V^2$ is a $\chi^2_n$ times $\sigma^2/n$.

Some cases where the variance is not homogeneous can be handled similarly.

Abstract 16
Session D5

Dynamic monetary risk measures for bounded discrete-time processes

PATRICK CHERIDITO (speaker)

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We study time-consistency properties of processes of monetary risk measures that depend on bounded discrete-time processes describing the evolution of financial values. The time horizon can be finite or infinite. We call a process of monetary risk measures time-consistent if it assigns to a process of financial values the same risk irrespective of whether it is calculated directly or in two steps backwards in time, and we show how this property manifests itself in the corresponding process of acceptance sets. For processes of coherent and convex monetary risk measures admitting a robust representation with sigma-additive linear functionals, we give necessary and sufficient conditions for time-consistency in terms of the representing functionals.
Modelling catastrophe claims with left-truncated severity distributions

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We present a procedure for consistent estimation of the severity and frequency distributions for incomplete data samples that follow a homogeneous Poisson processes with left-truncated claim amounts, with an unknown number/fraction of missing data and a known cutoff level H, described in [1]. Claims are modelled with truncated distributions F using Dempsters Expectation-Maximization algorithm [2], or direct numerical integration, and the number of missing data points is proportional to $F(H)$. The complete frequency is obtained by scaling the observed frequency by $\left\{1 - F(H)\right\}^{-1}$. It is shown that ignoring the missing data results in understated estimates of the upper quantiles of the aggregated claims distribution. The effects are more significant for heavier-tailed distributions. We extend the methodology to non-homogeneous Poisson processes. The empirical study applies the procedure to the USA natural catastrophe data obtained from Insurance Services Office Inc. for the period 1990-1999. The dollar threshold for defining catastrophes is set at $25 million. The intensity process is modelled by a deterministic sinusoidal rate function, studied in [3]. Claim magnitudes are calibrated using a variety of truncated distributions including the very heavy-tailed log-$\alpha$ Stable law. Under the correct data specification, the fraction of missing data is estimated to account for up to 80% of the complete data set. Goodness of fit for the claim amounts is tested using the in-sample goodness-of-fit techniques for the left-truncated samples developed in [4], and out-of-sample forecasting. For a hypothesized scenario, it is demonstrated that ignoring the $25 million threshold leads to the estimates of the ruin probabilities very highly underestimated, with the extent of the underestimation being more severe for heavier-tailed distributions.

What is always stable in nonlinear filtering?

PAVEL CHIGANSKY (speaker)

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ROBERT LIPTSER

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Let \((X,Y) = (X_n, Y_n)_{n \geq 0}\) be a discrete time Markov process with the Markov signal component \(X\) and observation component \(Y\) and let \(\pi_n\) the regular conditional distribution of \(X_n\) given \(\mathcal{F}_n^Y = \sigma\{Y_1, ..., Y_n\}\). The measure valued process \(\pi = (\pi_n)_{n \geq 0}\) satisfies the recursive equation, called nonlinear filter. Much research have been done recently about the stability properties of the nonlinear filtering equation with respect to its initial condition. Most of the results are obtained by treating the equation as a random dynamical system. They show that stability properties are not at all obvious, sometimes contradicting the intuition and indicating strong dependence on the signal state space, its ergodic properties and observations regularity. Nevertheless it turns out that certain functional of \(\pi_n\) is stable under very general conditions. We give a simple probabilistic proof of this fact and discuss some of its consequences.
Skorokhod embeddings with Chacon-Walsh style constructions

ALEXANDER COX (speaker)

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We consider the Skorokhod embedding problem for general starting and target measures. In particular, we provide necessary and sufficient conditions for a stopping time to be minimal in the sense of Monroe [4]. The resulting conditions have a nice interpretation in the graphical picture of Chacon and Walsh [2].

Further, we demonstrate how the construction of Chacon and Walsh can be extended to any (integrable) starting and target distributions, allowing the constructions of Azema-Yor [1], Jacka [3] and Vallois [5] to be viewed in this context, and thus extended easily to general starting and target distributions. In particular, we describe in detail the extension of the Azema-Yor embedding in this context, and show that it retains its optimality property.

We also describe a general construction in the Chacon-Walsh framework — based on the local time of a skew Brownian motion — which includes as special cases the Azema-Yor and Vallois constructions.

Excess entropy, ergodic decomposition, and universal codes

Lukasz Debowski (speaker)

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Consider stationary process \((X_k)_{k \in \mathbb{Z}}\) and let \(X_{m:n} := (X_k)_{m \leq k \leq n}\). Excess entropy \(E := I(X_{-\infty:0}; X_{1:\infty})\) is the mutual information between the \(\sigma\)-fields of past and future [5, 1]. We have \(E = \lim_{n \to \infty} E(n)\), \(E(n) := I(X_{-n+1:0}; X_{1:n})\) [5]. If finite differential entropy \(H(n) := H(X_{1:n})\) exists then \(E(n) = 2H(n) - H(2n)\) and \(E\) is the deviation of \(H(\cdot)\) from the linear growth, \(E = \lim_{n \to \infty}[H(n) - hn]\), \(h := \lim_{n \to \infty} H(n)/n\) [1]. Excess entropy is a natural measure of long memory, especially for discrete processes. It is finite for Gaussian ARMA [4] and hidden Markov processes but it may be infinite even for \(X_i\) having finite range [1]. It is conjectured that \(E(n) \propto \sqrt{n}\) for human language production [6, 2].

The properties of excess entropy for discrete and Gaussian processes have been studied in [3, 1]. In our talk, we shall focus on the links with ergodic decomposition [7] and universal coding. Let \(F\) be the random ergodic measure of \((X_k)_{k \in \mathbb{Z}}\), \(h(F)\) and \(E(F)\) being its entropy rate and excess entropy. Then \(h = \langle h(F) \rangle\) but \(E \geq \bar{H}(F) + \langle E(F) \rangle\), where \(\bar{H}(Y) := I(Y; Y)\) and \(Y\) is the expectation of \(Y\). In particular, \(E = \infty\) for the processes of form \(X_i = (N_i, Z_N)\), where \(N_i \in \mathbb{N}\) are IID with \(P(N_i = n) > 0\) for all \(n\) and \((Z_k)_{k \in \mathbb{N}}\) is Bernoulli process with \(P(Z_k = 0) = P(Z_k = 1) = 1/2\).

The divergence of \(E(n)\) affects universal coding of the underlying process. Let \(H^C(n)\) be the expected length of code \(C\) for \(X_{1:n}\). If \(C\) is universal (e.g. Lempel-Ziv) then \(\lim_{n \to \infty} H^C(n)/n = h\) for any stationary process but for the expected excess code length \(E^C(n) := 2H^C(n) - H^C(2n)\) we have \(\lim \sup_{n \to \infty}[E^C(n) - E(n)] \geq 0\). By that inequality, we can infer the famous Zipf-Mandelbrot law for word counts in human speech provided that there are no spaces between the words but \(E(n) \propto \sqrt{n}\) holds approximately [2, 8].

Universality for Mathematical and Physical systems

PERCY DEIFT (speaker)

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All physical systems in equilibrium obey the laws of thermodynamics. In other words, whatever the precise nature of the interaction between the atoms and molecules at the microscopic level, at the macroscopic level, physical systems exhibit universal behavior in the sense that they are all governed by the same laws and formulae of thermodynamics. The speaker will recount some recent history of universality ideas in physics starting with Wigner’s model for the scattering of neutrons off large nuclei and show how these ideas have led mathematicians to investigate universal behavior for a variety of mathematical systems. This is true not only for systems which have a physical origin, but also for systems which arise in a purely mathematical context such as the Riemann hypothesis, and a version of the card game solitaire called patience sorting.
Abstract 22
Session A4

**Fragmentation associated to Lévy processes using snake)**

JEAN-FRANÇOIS DELMAS (speaker)

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Romain Abraham

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We consider the height process and the exploration process of a Lévy process with no negative jumps, and it associated continuous random tree representation. Using Lévy snake tools developed by Duquesne - Le Gall, we construct a fragmentation process by cutting at node the continuous random tree. In the stable case, we recover an auto-similar fragmentation described by Miermont.
Contingent claims valuation in a class of nonnormal autoregressive multifactor forward rate models

GIULIANO DE ROSSI (speaker)

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This paper characterises a class of discrete time models of the term structure of interest rates based on a set of autoregressive factors with nonnormal innovations. Discrete time models are widely used in macroeconomics (see e.g. [2] and references thereof) to analyse risk premia, the expectations hypothesis, information content of interest rates, etc. Most empirical articles use either Gaussian models or models characterised by square-root diffusions as in [3], so that the distribution of the innovations is implicitly constrained to be either Gaussian or non-central $\chi^2$. The framework proposed in this paper allows a greater flexibility in modelling the distribution of bond yields, so as to take into account the available empirical evidence (e.g. in [7]) of strong nonnormalities.

The difference between the approach proposed here and the one adopted in the mathematical finance literature in continuous time ([1], [6]) is that in the former the derivation of bond prices hinges on an assumption of rational behaviour, while in the latter an arbitrary change of measure is imposed. The argument is based on the extended Girsanov principle introduced by [4] as a discrete time version of the Girsanov theorem. It is applied to bond pricing, along the lines of [3], in a discrete time, incomplete markets setting.

The $d$ stochastic factors are assumed to follow $x_{it} = \phi_i x_{i,t-1} + \varepsilon_{it}$, where $\phi_i$, $i = 1, \ldots, d$, $|\phi_i| < 1$, are constant and $\varepsilon_t$ is i.i.d. over time with support $\mathbb{R}^d$. Assume that the expected value $E[\exp(-\alpha^t \varepsilon_t)]$ exists $\forall \alpha \in \mathbb{R}^d_+$. The resulting bond prices have a simple expression, $b^n_t = \exp\left(A(n) + \sum_{i=1}^d B_i(n)x_{it}\right)$ where $n$ is time to maturity and $A(n)$, $B_i(n)$, $i = 1, \ldots, d$, are determined by the information available at time $t - 1$.

The examples provided show how this framework can be used to model higher moments of the innovations directly, to model dependence between short and long rates through copulae and to model fat tails through scale mixtures of normals.

Nonlinear ARMA doubly stochastic and state dependent models: a new general approach to nonlinear time series analysis

FRANCESCO MARTA LILJA DI LASCIO (speaker)

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We construct a general class of nonlinear models, called ‘nonlinear ARMA doubly stochastic and state dependent models’ (indicated with the acronym NLARMADSSD), which contain, as special cases, ARMA models [1], nonlinear ARMA models, time varying coefficients models and random coefficient models, bilinear models, threshold, exponential, random coefficient and smooth transition AR models [2], state dependent models [4] and doubly stochastic models [5]. We work to construct a general model that can be fitted to data without any specific prior assumptions about the specific form of nonlinearity and that can be used to give us an “overview” of the character of the nonlinearity inherent in the data. This model has a polynomial representation of grade \((p + q)\) given by a sum of a polynomial in \(X\) of grade \(p\) and a polynomial in \(\varepsilon\) of grade \(q\) plus a local intercept term \(\mu\) and a noise term \(\varepsilon_t\). So, its parametric representation is the following:

\[
X_t = \mu\left(t, \xi_{t-1}\right) + \sum_{p=1}^{r} \sum_{i_1, \ldots, i_p} \theta_{i_1, \ldots, i_p} \left(t, \xi_{t-1}\right) \prod_{\nu=1}^{p} X_{t-i_\nu} + \sum_{q=1}^{m} \sum_{j_1, \ldots, j_q} \psi_{j_1, \ldots, j_q} \left(t, \xi_{t-1}\right) \prod_{\eta=1}^{q} \varepsilon_{t-j_\eta} + \varepsilon_t
\]

where \(i_a = 1, 2, \ldots, l\) and \(j_b = 1, 2, \ldots, m\). This model can be interpreted as a locally nonlinear ARMA model in which the evolution of the process \(\{X_t\}\) is governed by a set of AR coefficients \(\{\theta_{i_a}\}\), by a set of MA coefficients \(\{\psi_{j_b}\}\) and a local mean \(\mu\), all of which is a stochastic process of order \((l + m)\) that depend on the vector \(\xi_{t-1} = (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots, \varepsilon_{t-m}, X_{t-1}, X_{t-2}, \ldots, X_{t-l})\) that we call ‘state vector’ at the time \((t-1)\) by analogy with the state dependent models of M.B.Priestley [4]. We assume that \(\{X_t\}\), \(\{\varepsilon_t\}\), \{\theta\} and \{\psi\} are defined on a common space of probability \((\Omega, \mathcal{B}, P)\), and denote by \(\mathcal{B}_t^i\) with \(i = X, \theta, \psi\) the \(\sigma\)-algebras generated by \(\{X_u, u \leq t\}\), \(\{\theta_u, u \leq t\}\) and \(\{\psi_u, u \leq t\}\), respectively.

Gaussian stationary processes: discrete approximations, special wavelet decompositions and simulation

GUSTAVO DIDIER (speaker)

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We establish special wavelet-based decompositions of Gaussian stationary random processes in continuous time. The special decompositions have a multiscale structure with an approximation (low-frequency) term superimposed by detail terms at finer scales (high frequencies). The random coefficients in the detail terms are independent Gaussian random variables. However, unlike usual wavelet decompositions, detail terms across different scales are expressed in terms of many different wavelet-like functions. The random coefficients in the approximation term, referred to as discrete approximations, converge to the continuous-time Gaussian process almost surely, uniformly on compact intervals and exponentially fast. There is also a Fast Wavelet Transform-like algorithm to compute a discrete approximation at one scale from that at a coarser scale in an efficient and simple manner. Several examples of Gaussian random processes are considered. The convergence of their discrete approximations is illustrated through simulations.
Term Structures of Conditional Probabilities of Corporate Default

Darrell Duffie (speaker)

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This talk, based on research with Leandro Saita, presents new statistical methods and evidence, based on doubly-stochastic correlated intensity models, regarding term structures of conditional probabilities of default by U.S. corporations. New evidence will be provided on the correlating effects of firm-specific and macro-economic covariates, with implications for the probability distribution of the financial performance of portfolios of corporate debt and credit derivatives.
This talk is concerned with the link between implied volatilities and the spot volatility. Such a link is of great practical interest since it relates the fundamental quantity for pricing derivatives (the spot volatility) which is not observable, to directly observable quantities (the implied volatilities).

We first motivate our work by some examples. Then, we explain how the dynamics of the spot volatility and that of the implied volatility surface relate to each other. In particular, we write down the stochastic differential equation driving the spot volatility based on the shape of the implied volatility surface. This equation is a consequence of no-arbitrage constraints on the implied volatility surface right before expiry. As a byproduct, we give expansions formulas for the implied volatility surface in a general stochastic volatility model. This leads to discussions of some practical implications.
Recent results about the largest eigenvalue of large random covariance matrices and statistical applications

Noureddine El Karoui (speaker)

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In modern statistical practice, one often encounters \( n \times p \) data matrices with \( n \) and \( p \) both large. Classical statistical multivariate analysis [1] fails to apply in this setting.

Using random matrix theory, [2] and [3] recently shed light on the behavior of the largest eigenvalue of a complex Wishart matrix when the true covariance is \( \text{Id} \). Specifically, when the entries of the \( n \times p \) matrix \( X \) are i.i.d \( \mathcal{N}(0,1/\sqrt{2}) + i\mathcal{N}(0,1/\sqrt{2}) \) and \( n/p \to \rho \in (0,\infty) \), they showed - among other things - that \( l_{1}^{(n,p)} \), the largest eigenvalue of the empirical covariance matrix \( X^*X \), converges in distribution to \( W_2 \) (after proper recentering and rescaling), a random variable whose distribution is the Tracy-Widom law appearing in the study of the Gaussian Unitary Ensemble.

We will discuss some extensions of this result. First, we will explain that in this situation, one can find centering and scaling sequences \( \mu_{n,p} \) and \( \sigma_{n,p} \) such that \( P((l_{1}^{(n,p)}) - \mu_{n,p})/\sigma_{n,p} \leq s \) tends to its limit at rate at least \( 2/3 \).

Second, we will explain that the assumption that \( \rho \neq \infty \) can be removed. This is true for both the complex and the real case (where the entries of \( X \) are i.i.d \( \mathcal{N}(0,1) \)), which was first investigated in [3].

Last, we will consider the case where the rows of \( X \) are \( p \)-dimensional independent vectors with distribution \( \mathcal{N}(0,\Sigma_p/\sqrt{2}) + i\mathcal{N}(0,\Sigma_p/\sqrt{2}) \). For a quite large class of matrices \( \Sigma_p \) (including for instance well-behaved Toeplitz matrices), it turns out that \( l_{1}^{(n,p)} \) converges again to \( W_2 \). We will give (numerically) explicit formulas for centering and scaling sequences in this setting and highlight connections between this result and work of Bai, Silverstein and co-authors about a.s behavior of the largest eigenvalue of random covariance matrices.

Finally, time permitting, we will illustrate how these and related theoretical insights might be used in statistical practice.

Spatial branching in random media

JÁNOS ENGLÄNDER(speaker)

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When a spatial branching process is put into a random Poissonian environment, it exhibits intriguing features. We will discuss a model where “mild” obstacles affect the reproduction and will also review some related similar models.
Limit shapes of coagulation-fragmentation processes on the set of partitions

ERLIHSON MICHAEL (speaker)

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This is a joint work with Boris Granovsky. We find the limit shape (in the sense of Vershik [1]) for the invariant measure $\mu_N$ of the processes in the title, when the parameter function is of the form $a_k \sim k^{p-1}$, $p > 0$, $k \to \infty$ (=Expansive case). We prove the functional central limit theorem for the fluctuations of random partitions (=Young diagrams) around the limit shape, with respect to the above measure $\mu_N$. The results are obtained with the help of Khintchine’s probabilistic method (see [2],[3] and references therein). We also discuss (in a general setting) the interplay between the following three concepts related to the clustering of groups: limit shape, threshold and gelation.

Core function of stationary non-Gaussian process

ZDENĚK FABIÁN (speaker)

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Let \( S \subset \mathbb{R} \) be an open interval of the real line \( \mathbb{R}, \Theta \subseteq \mathbb{R}^m \) a convex set and \( F_\theta, \theta \in \Theta \) a regular distribution supported by \( S \), with possibly infinite moments.

Consider an autoregressive process \( X_t = b_1X_{t-1} + ... + b_pX_{t-p} + Y_t \) where \( Y_t \) are i.i.d. random variables with distribution \( F_\theta \) known apart from the values of parameters \( \theta = \theta_1, ..., \theta_m \). The task is to estimate \( b_1, ..., b_p \) from a realization \( x_t = x_1, ..., x_n \) of \( X_t \).

Instead from \( x_t \), we estimate \( b_1, ..., b_p \) from a realization \( T_F(x_t) \) of the core function \( T_F(X_t) \), a generally non-linear transformation of the process \( X_t \).

To construct \( T_F(x_t) \), we at first find an estimate \( \hat{\theta} \) of parameter \( \theta \) of distribution \( F_\theta \). According to [3], we show that a distribution can be usually reparametrized by such a way that it has a parameter representing its central tendency even if its mean does not exist. The estimate of this parameter represents the zero level of \( T_F(x_t) \).

Let \( \eta : S \to \mathbb{R} \) be Johnson transformation [4] for the given support (for example, if \( S = (0, \infty) \) then \( \eta(x) = \log(x) \)). Core function \( T_F(y) \) of random variable \( Y \) with support \( S \) was defined in [2] as the transformed score function \( T_G = -g'/g \) of distribution \( G \) with density \( g \) of a “prototype” random variable \( \eta(Y) \), that is, \( T_F(y) = T_G(\eta(y)) \).

In the second step we assume that \( X_t \) are distributed according to \( F_\hat{\theta} \), find the pertaining core function of the process \( T_F_\hat{\theta} \), construct its realization \( T_F_\hat{\theta}(x_t) \) and find the estimates of \( b_1, ..., b_p \). Comparison of the estimated spectral densities with those obtained by the usual methods is given and robustness of the estimates of the coefficients for various families of distributions of \( Y_t \) is discussed.

The work was supported by the Czech Ministry of Education under Grant No. ME 701.

On optimal portfolios in a Lévy market via fictitious completion

ENRIQUE FIGUEROA-LOPEZ (speaker)

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The problem of optimal investment on a market consisting of a bond, a stock that follows a geometric Levy model, and certain fictitious stocks called power-jump assets was recently considered in [2]. Using their previous work [1] on the completeness of such a market, they derive explicit formulas for the optimum utility coming from the final wealth. In this work, we analyze the problem of utility maximization in the real market, consisting only of the stock and the bond, using fictitious completion. We consider state-dependent utility functions, and as a particular case, the minimization of the “shortfall risk” in replicating a contingent claim.

Random walk in random scenery

NINA GANTERT (speaker)

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Let \((Z_n)_{n \in \mathbb{N}_0}\) be a \(d\)-dimensional random walk in random scenery, i.e., \(Z_n = \sum_{k=0}^{n-1} Y(S_k)\) with \((S_k)_{k \in \mathbb{N}_0}\) a random walk in \(Z^d\) and \((Y(z))_{z \in Z^d}\) an i.i.d. scenery, independent of the walk. The walker’s steps have mean zero and finite variance. We identify the speed and the rate of the logarithmic decay of \(P(\frac{1}{n}Z_n > b_n)\) for various choices of sequences \((b_n)_n\) in \([1, \infty)\). Depending on \((b_n)_n\) and the upper tails of the scenery, we identify different regimes for the speed of decay and different variational formulas for the rate functions. In contrast to recent work by A. Asselah and F. Castell, we consider scenarios unbounded to infinity. It turns out that there are interesting connections to large deviation properties of self-intersections of the walk, which have been studied recently by X. Chen. The talk is based on joint work with Wolfgang König, Remco van der Hofstad and Zhan Shi.
A Relationship Between Finite and Infinite Dimensional Stochastic Differential Equations

L. Gawarecki (speaker)

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We examine the relationship between an infinite dimensional SDE with a solution $Y_t$ and a finite dimensional SDE with a solution $X_t$, driven by the same finite dimensional Brownian motion. We consider a countably Hilbertian space set-up, as in [2], in the specific case of the spaces $(S, S')$, and we match the solutions in the sense that $Y_t = \delta_{X_t}$, and their explosion times coincide. We show a specific example of a pair of finite/infinite dimensional equations and explore a relationship between our work and Walsh’s approach to SPDE’s and the Brownian density process [3].

We then prove the existence and uniqueness of solutions in the infinite dimensional case for more general coefficients, using the monotonicity and linear growth conditions and the techniques introduced in [1].

Finally we generalize our results to a case of a SDE driven by a local martingale with a solution being a process locally of compact support, a concept introduced by us in this work.

Optimal Controls for Stochastic Networks in Heavy Traffic.

Arka P. Ghosh (speaker)

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A. Budhiraja

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Stochastic networks are common in manufacturing, telecommunications & computer systems. These networks have a system manager, who can exercise dynamic control in the form of sequencing of jobs. Also, the networks are in “heavy traffic(HT)”. The goal of a system manager is to allocate service times of each server appropriately among different pending jobs so as to minimize suitable cost function defined in terms of holding costs in the buffer. Under HT, one can formally replace the network control problem by an analogous diffusion control problem (Brownian control problem (BCP), Harrison[88]). The solution to BCP provides key insights to finding good control policies for the network problem. The performance of such policy can then be studied analytically or numerically. However, there are very few works where the performance is studied analytically, and none where the diffusion control problem is more than 1-d. In the talk, an analytical study of the performance of a policy for "crisscross network" will be discussed where the diffusion model is 2-d. Also, extensions of such analysis to general networks will be discussed with some preliminary results.
Traffic Modeling for Queues

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In this talk, we will discuss the issue of how the choice of traffic model (i.e., a statistical description of the arriving traffic) impacts the behavior and performance of a queue. Various applications (in particular, the Internet) have demanded the use of models exhibiting long-range dependence and/or other heavy-tailed characteristics. The choice of model can have a dramatic impact on performance, rare-event dynamics, and statistical analysis. In addition, there is an interplay with the spatial and temporal scales of engineering relevance. We shall argue that the appropriate modeling of arriving traffic to a queue is critical to good predictive performance. The talk will draw upon large deviations ideas, conditional asymptotics, and heavy traffic theory.
Transportation cost inequalities and applications

Arnaud Guillin (speaker)

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We present here a review on recent results on $T_p$ Transportation cost inequalities, i.e. $\forall \nu, \mu$ satisfies

$$W_p(\nu, \mu) \leq \sqrt{2C \cdot H(\nu/\mu)}$$

where $W_p$ denotes the usual Wasserstein distance and $H$ the entropy. We present a characterization of $T_1$ obtained in [3], as well as results on $T_2$, stating that $T_2$ is strictly weaker than a logarithmic Sobolev inequality, proved in [2]. We will also give an application to concentration in Wasserstein distance for empirical measure of i.i.d.r.v., see [1].

Change-point detection in the Brownian motion model with two-sided alternatives

Olympia Hadjiliadis (speaker)

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Statistical surveillance finds applications in many different fields such as signal processing, quality control, financial decision making etc. This work employs the Brownian motion model in which after the unknown change point, the drift can increase or decrease by the same amount (symmetric change) or different amounts (non-symmetric change). The objective is to detect such a change as soon as possible while controlling the frequency of false alarms, by means of a stopping rule. An extended Lorden’s criterion is used as a performance measure ([1]). The best amongst the classical 2-CUSUM stopping rules used in the literature ([3]) is found both in the case of a symmetric and a non-symmetric change in the drift. The best 2-CUSUM stopping rule in the non-symmetric case is compared to a modified 2-CUSUM harmonic mean rule whose drift parameters are chosen so that it demonstrates the same detection delay under both the positive and the negative change ([2]). The latter is found superior. Moreover, in the symmetric case, it is shown that the difference in the performance between the unknown optimal scheme and the best 2-CUSUM stopping rule remains uniformly bounded as the frequency of false alarms tends to infinity, although both quantities become unbounded. In the non-symmetric case the asymptotic optimality is even stronger since the corresponding difference tends to zero.

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Branching Brownian motion with absorption

JOHN HARRIS (speaker)

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The subject of this talk is a branching Brownian motion (BBM) with killing, where individual particles move as Brownian motions with drift $-\rho$, perform dyadic branching at rate $\beta$ and are killed on hitting the origin.

By considering properties of the right-most particle and the extinction probability, we provide a probabilistic derivation of the classical result that the ‘one-sided’ FKPP travelling-wave equation of speed $-\rho$ (with solutions $f : [0, \infty) \to [0, 1]$ satisfying $f(0) = 1$ and $f(\infty) = 0$) has a unique solution with a particular asymptotic when $\rho < \sqrt{2\beta}$, and no solutions otherwise. Our analysis is in the spirit of the standard BBM studies of Harris [2] and Kyprianou [3], and includes a change of measure inducing a spine decomposition that, as a by product, shows that the asymptotic speed of the right-most particle in the killed BBM is $\sqrt{2\beta} - \rho$ on the survival set.

We also introduce, and discuss the convergence of, an additive martingale for the killed BBM, $W_\lambda$, that facilitates some results on the almost-sure exponential growth rate of the number of particles of speed $\lambda \in (0, \sqrt{2\beta} - \rho)$.

Finally, we prove an asymptotic for the probability of finding the right-most particle with speed $\lambda > \sqrt{2\beta} - \rho$. This result, combined with Chauvin and Rouault’s [1] arguments for standard BBM, readily yields an analogous Yaglom-type conditional limit theorem for the killed BBM; and also proves $W_\lambda$ to be the limiting Radon-Nikodým derivative when conditioning the right-most particle to travel at speed $\lambda > \sqrt{2\beta} - \rho$ into the distant future.

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Application of ‘spines’ in branching diffusions

SIMON C. HARRIS (speaker)

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We give a new, intuitive and relatively straightforward proof of a path large-deviations result for branching Brownian motion (BBM) that can be thought of to extend Schilder’s theorem for a single Brownian motion. Our conceptual approach provides an elegant application of a change of measure technique that induces a ‘spine’ decomposition and builds on the new foundations for the use of spines in branching diffusions recently developed in Hardy and Harris [1, 2], itself inspired by related works of Kyprianou [4] and Lyons et al [5, 3, 6]. We also hope to indicate some further applications of such ‘spine’ techniques.

   http://www.bath.ac.uk/~massch/Research/Papers/spine-foundations.pdf
   http://www.bath.ac.uk/~massch/Research/Papers/spine-Lp-cgce.pdf
Considerable research effort has focused on the forecasting of asset return volatility. Debate in this area centers around the performance of time series models, in particular GARCH, relative to implied volatility from observed option premiums. Existing literature suggests that the performance of any volatility forecast is sensitive. This paper rigorously examines the forecasting performance of four GARCH(1, 1) models (GARCH, EGARCH, GJR and APARCH) used with three distributions (Normal, Student-t and Skewed Student-t). We explore and compare different possible sources of forecasts improvements: asymmetry in the conditional variance, fat-tailed distributions and skewed distributions. The Jordanian stock index are studied using daily data over a 12-years period from 1992-2003. The results provide considerable insight into the performance of these alternative volatility forecasting procedures over forecasts improvement. The evidence suggests that improvements of the overall estimation are achieved when asymmetric GARCH are used and when fat-tailed distributions are taken into account in the conditional variance. Moreover, it is found that GJR and APARCH give better forecasts than symmetric GARCH. Finally increased performance of the forecasts is not clearly observed when using non-normal distribution.
Hölder regularity for a set-indexed fractional Brownian motion

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In [2], we defined and proved the existence of a fractional Brownian motion (fBm) indexed by a collection $A$ of closed subsets of a measure space $T$, in the frame of [3]. It is defined as a centered Gaussian process $B^H = \{B^H_U; U \in A\}$ such that

$$\forall U, V \in A; \quad E[B^H_U B^H_V] = \frac{1}{2} \left[ m(U)^{2H} + m(V)^{2H} - m(U \triangle V)^{2H} \right]$$

where $H \in (0,1)$, $\triangle$ is the symmetric difference between sets, and $m$ is a measure on $T$. This process is a generalization of the set-indexed Brownian motion, when the condition of independence is relaxed. As the classical real-parameter fBm, it satisfies fractal properties such that stationarity and self-similarity.

Under assumptions on the collection $A$, we study Hölder-continuity and defined Hölder exponents for set-indexed processes in the case of the pseudo-distance $U, V \mapsto m(U \triangle V)$ between elements of $A$. We prove the existence of almost sure values for pointwise and local exponents. We apply this result to show that the regularity of our set-indexed fractional Brownian motion is equal to $H$. Finally, we compare regularity of a set-indexed process to the classical Hölder exponents of projections on flows.

Extremal behavior of stochastic integrals driven by regularly varying Lévy processes

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The notion of regular variation for stochastic processes with sample paths in the space $D[0,1]$ of càdlàg functions was first introduced by de Haan and Lin [1] in connection with max-stable stochastic processes. It provides a useful framework for studying the extremal behavior of heavy-tailed stochastic processes. In [2] it was adopted to study extremes of a class of regularly varying Markov processes (including additive and Lévy processes) as well as some filtered regularly varying Lévy processes.

In this talk we present some new results on the extremal behavior of a multivariate stochastic integral $(Y \cdot X)$ driven by a multivariate Lévy process $X$ that is regularly varying with index $\alpha > 0$. For predictable integrands $Y$ satisfying the moment condition

$$E\left[ \sup_{t \in [0,1]} |Y_t|^\alpha + \delta \right] < \infty$$

for some $\delta > 0$, we show that the extremal behavior of the stochastic integral is due to one big jump of the driving Lévy process and we determine its limit measure associated with regular variation on the space $D[0,1]$. The results show that, conditional on $\sup_{t \in [0,1]} |(Y \cdot X)_t|$ being large, the extreme behavior of the stochastic integral $(Y \cdot X)$ is well approximated by that of the random step function $Y_\tau \Delta X_\tau 1_{[\tau,1]}$, where $\tau$ denotes the time of the largest jump of the Lévy process $X$.

Simulation-based Uniform Estimates of Value Functions of Markov Decision Processes

Rahul Jain (speaker)

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Necessary and sufficient conditions for a uniform law of large numbers to hold for a class of measurable Boolean functions were first obtained by Vapnik and Chervonenkis [5]. It was a generalization of the classical Glivenko-Cantelli theorem. This was later extended to bounded real-valued functions by Pollard and others [3, 4]. It was shown that the rate of convergence depends on the \( \varepsilon \)-covering number of the function class introduced by Kolmogorov and Tihomirov [2]. We provide the beginnings of an empirical process theory for Markov decision processes [1]. We consider similar uniform law of large number results for particular functionals of Markov decision processes.

The value function \( V_\pi \) of a Markov decision process assigns to each policy \( \pi \) (in some policy space \( \Pi \)) its expected discounted reward. This expected reward can be estimated as the empirical average \( \hat{V}_\pi^{(n)} = \frac{1}{n} \sum_{i=1}^{n} V_{\pi}^i \) of the reward obtained from many independent simulation runs. We derive sufficient conditions such that

\[
P\{\sup_{\pi \in \Pi} |\hat{V}_\pi^{(n)} - V_\pi| > \varepsilon \} \to 0
\]

as \( n \to \infty \) with respect to simulation measure \( P \). When uniform convergence is obtained, we also obtain the rate of convergence in terms of \( P \)-dimension of the policy class. Surprisingly, we find that how sample trajectories of a Markov process are obtained from simulation matters for uniform convergence: There are good simulation models (for which one may get uniform convergence) and bad simulation models (for which one may not get uniform convergence for the same set of Markov processes). This phenomenon seems to be the first such observation in the theory of empirical processes [4].

Uniform convergence results are also obtained for the average reward case, for some partially observed processes, and for Markov games.

Semimartingale Reflecting Brownian Motions (SRBMs) in domains with piecewise smooth boundaries are of interest in applied probability because of their role as heavy traffic approximations for stochastic networks. Here, under some sufficient conditions, an invariance principle is shown for such SRBMs. More precisely, we show that a process that satisfies perturbed versions of the SRBM conditions is close in distribution to an SRBM. A crucial ingredient in the proof of this result is a local oscillation inequality for solutions of perturbed Skorokhod problems. The problem of existence and uniqueness of such SRBMs is also considered in order to apply the invariance principle. Examples of application of the invariance principle include an Internet congestion control model and an input-queued packet switch model.
A Characterization of the Infinitely Divisible Squared Gaussian Processes

HAYA KASPI (speaker)

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We show that up to a multiplication by a deterministic function a Gaussian process has an infinitely divisible square if, and only if, its covariance function is the potential density of a transient symmetric Markov process. Gaussian processes with a covariance equal to the potential density of a transient symmetric Markov process play an important role in the study of the local time process of the Markov processes, using the Dynkin Isomorphism Theorem. Our result, characterizes the Gaussian processes associated with symmetric Markov processes. Joint with Nathalie Eisenbaum.
On Spectrum of the Covariance Operator for Nilpotent Markov Chain

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In [1] we study the spectrum of the covariance operator of the nilpotent Markov Chain. This is a special case of the general Markov Chain with the Doeblin condition and under the assumption that there exist a finite $k$ such that for all $l \geq k$ $(P - \Pi)^l = 0$, where $\Pi$ is an invariant distribution and $P$ is the transition operator associated with the chain. The chains with this property arise naturally in testing Random Number Generators (RNG) when it is understood that a finite sequence of digits is produced to form a word. We specialize our approach to the study of weak convergence with the improved estimation of the remainder term for the Marsaglia [2] permutation type test statistics.

A complete analysis of the spectrum of the covariance operator is presented for the $L^2(X, \mu)$ space. We give an explicit decomposition of $L^2(X, \mu)$ into the direct sum of the eigenspaces associated to the eigenvalues of the covariance operator. This decomposition allows for the development of efficient computational algorithms when establishing the limiting distribution of the functional Central Limit Theorem generated by a general Markov Chain.

We also present some results of Berry-Esseen type for general Markov chains with and without nilpotent property [3], [4].

In this talk we are concerned with the problem of reconstruction of the intensity of a Neyman-Scott trigger process. This is a doubly stochastic Poisson process, whose (unobservable) stochastic intensity is a shot noise process. Such processes were used for the modeling of cluster phenomena. Linear first order partial differential equations describe the evolution of the unnormalized conditional moment generating function in between the observed events of the point process. While at jump times a nonlinear updating is called for. The cases under consideration are examples of explicitly computable nonlinear filters. Empirical results exhibit a clear better performance of optimal filters compared with the best linear filter.

In the second part of the talk we address the problem of intensity parameter estimation. Since the intensity process is not directly observable, we are faced with inference for a partially observed process. In practical situation, we have to resort on MC - methods. We conclude the talk with the presentation of some empirical results.
A predator-prey model on a homogeneous tree.

GEORGE KORDZAKHIA (speaker)

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There are two types of particles interacting on a homogeneous tree of degree \(d + 1\). The particles of the first type colonize the empty space with exponential rate 1, but cannot take over the vertices that are occupied by the second type. The particles of the second type spread with exponential rate \(\lambda\). They colonize the neighboring vertices that are either vacant or occupied by the representatives of the opposite type, and annihilate the particles of the type 1 as they reach them. There exists a critical value \(\lambda_c = (2d - 1) + \sqrt{(2d - 1)^2 - 1}\) such that the first type survives with positive probability for \(\lambda < \lambda_c\), and dies out with probability one for \(\lambda > \lambda_c\). We also find the growth profile which characterizes the rate of growth of the type 1 in the space-time on the event of survival.
Recent advances in nano-technology allow scientists for the first time to follow a biochemical process on a single molecule basis. These advances also raise many challenging data-analysis problems and call for a sophisticated statistical modeling and inference effort. First, by zooming in on single molecules, recent single-molecule experiments revealed that many classical models derived from oversimplified assumptions are no longer valid. Second, the stochastic nature of the experimental data and the presence of latent processes much complicate the inference. In this talk we will use the modeling of sub-diffusion phenomenon in enzymatic reaction to illustrate the statistics and probability challenges in single-molecule biophysics.
Fractional Laplace Motion

TOMASZ J. KOZUBOWSKI (speaker)

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MARK M. MEERSCHAERT, KRZYSZTOF PODGÓRSKI

Fractional Laplace motion (FLM) is a new stochastic process obtained by subordinating fractional Brownian motion (FBM) to a gamma process. Developed recently to model hydraulic conductivity fields in geophysics, FLM also seems to be an appropriate model for certain financial time series. Its one dimensional distributions are scale mixtures of normal laws, where the stochastic variance has the generalized gamma distribution. These one dimensional distributions are more peaked at the mode than a Gaussian, and their tails are heavier. This talk is an overview of the basic properties of the FLM process, which include covariance structure, densities, moments, stochastic representations, infinite divisibility, stochastic self-similarity, and tail behavior. We shall also discuss the corresponding fractional Laplace noise, which may exhibit long-range dependence, and, time permitting, methods for simulating FLM.
Gambler’s Ruin with Catastrophes

ALAN KRINIK (speaker)

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BLAKE HUNTER, CHAU NGUYEN, JENNIFER SWITKES, HUBERTUS VON BREMEN

Department of Mathematics and Statistics, California State Polytechnic University, Pomona

Consider a birth-death Markov chain on (0, 1, 2, 3, ..., N) with catastrophe probabilities to state 0. Assume birth probabilities are all $\alpha$, death probabilities are always $\beta$, and each catastrophe probability is $\gamma$. Starting at an intermediate state $x$, we present a formula for the ruin probabilities of this Markov chain in infinite or finite time. The method generalizes to related transition diagrams.
Macroscopic current fluctuations in stochastic lattice gases

Claudio Landim (speaker)

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The large deviation properties of equilibrium (reversible) lattice gases are mathematically reasonably well understood. Much less is known in non–equilibrium, namely for non reversible systems. In this talk we consider a simple example of a non–equilibrium situation, the symmetric simple exclusion process in which we let the system exchange particles with the boundaries at two different rates. We prove a dynamical large deviation principle for the empirical density which describes the probability of fluctuations from the solutions of the hydrodynamic equation. The so called quasi potential, which measures the cost of a fluctuation from the stationary state, is then defined by a variational problem for the dynamical large deviation rate function. By characterizing the optimal path, we prove that the quasi potential can also be obtained from a static variational problem.

We study current fluctuations in lattice gases in the macroscopic limit. We derive large deviation estimates for the space–time fluctuations of the empirical current. Large time asymptotic estimates for the fluctuations of the time average of the current follow.

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Session D1

**Insider’s Hedging in Jump Diffusion Model**

Kiseop Lee (speaker)

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We formulate the optimal hedging problem when the underlying stock price has jumps, especially for insiders who have more information than general public. The jumps in the underlying price process depend on another diffusion process, which models a sequence of firm specific information. This diffusion process is observed only by insiders. Nevertheless, the market is incomplete to insiders as well as to general public. We use the local risk minimization method to find closed forms of optimal hedging strategies of both insiders and honest traders. We also provide numerical examples.
Conditioned Brownian trees

JEAN-FRANÇOIS LE GALL(speaker)

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We consider a Brownian tree consisting of a collection of one-dimensional Brownian paths started from the origin, whose genealogical structure is given by the Continuum Random Tree (CRT). This Brownian tree yields a convenient representation of the so-called Integrated Super-Brownian Excursion (ISE), which can be viewed as the uniform probability measure on the tree of paths. We give different approaches that lead to the definition of the Brownian tree conditioned to stay on the positive half-line. In particular, we establish a Verwaat-like theorem, which implies that this conditioned Brownian tree can be obtained by re-rooting the unconditioned one at the vertex corresponding to the minimal spatial position. We then discuss an invariance principle showing that the conditioned Brownian tree is the weak limit of certain conditioned discrete trees. To this end, we consider Galton-Watson trees associated with a critical offspring distribution and conditioned to have exactly $n$ vertices. These trees are embedded in the real line by affecting spatial positions to the vertices, in such a way that the increments of the spatial positions along edges of the tree are independent variables distributed according to a symmetric probability distribution on the real line. We then condition on the event that all spatial positions are nonnegative. Under suitable assumptions on the offspring distribution and the spatial displacements, these conditioned spatial trees converge as $n$ tends to infinity, modulo an appropriate rescaling, towards the conditioned Brownian tree. Applications are given to asymptotics for random quadrangulations.

Simultaneous Bootstrap Confidence Region for Covariance Matrix

SHANMEI LIAO (speaker)

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There are two problems in generating confidence region for covariance matrices by bootstrapping method: (1) A set of bootstrap confidence intervals generated for each component of a covariance matrix need not induce a confidence set of positive definite covariance matrices. (2) Besides controlling the overall coverage probability of the confidence region, it is desirable to keep equal the coverage probabilities of the individual confidence intervals that define the simultaneous region. In this paper, I stress these two problems by using unconstrained parameterizations for covariance matrices, such as Log-Cholesky parametrization and spherical parametrization, to assure the positive definiteness of the covariance matrices estimators. As an application, these confidence regions are used to test an assumption on the structure of a covariance matrix.

Pricing derivative securities in incomplete markets: a simple approach

JUYOUNG LIM (speaker)

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Indifference pricing is a utility based pricing rule for derivative securities in incomplete markets. In contrast to advance in theoretical study such as Musiela and Zariphopoulou (2004) [2] there has been little progress in numerical method to implement the framework in practice. We present a discrete time version of indifference pricing, reminiscent of Cox, Ross and Rubinstein (1979) [1], which illuminates the key ingredients of indifference pricing and naturally leads to an efficient numerical method to compute indifference price. The scheme is shown to be consistent with Black Scholes pricing for replicable payoff and hits a subtle balance between arbitrage free pricing and actuarial certainty equivalence. We also present the results of numerical implementation for basket/spread option when a component of the basket is non tradable along with demonstration of convergence to continuous time price when time increment goes to zero.

Natural questions and fewer answers on reinforced walks

VLADA LIMIC(speaker)

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Reinforcement is observed frequently in nature and society, where beneficial interactions tend to be repeated. Reinforcement models have been studied by psychologists, economists, and more recently by biologists and mathematicians.

A prototype reinforcement process is the Polya urn. A more complex class of models are reinforced random walks. Edge reinforced random walker on a graph remembers the number of times each edge was traversed in the past, and decides to make the next random step with probabilities favoring places visited before.

This talk will describe some of the recent progress made by various probabilists studying reinforcements, and offer many more questions than answers.
Weak Convergence of $n$-Particle Systems Using Bilinear Forms

Jörg-Uwe Löbus (speaker)

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A method is developed to prove convergence in distribution of $n$-particle processes to deterministic stationary paths as $n \to \infty$. For this, weak convergence of invariant measures of $n$-particle systems is translated into a Mosco type convergence of a general class of bilinear forms. This Mosco type convergence of bilinear forms results in a certain convergence of the resolvents of the $n$-particle systems which finally yields their convergence in distribution to stationary paths. The method is applied to provide limits in distribution for a Fleming-Viot type particle system, a Ginzburg-Landau type diffusion, and a particle approximation of the stationary solution to the Boltzmann equation.

An effective approach to studying stochastic partial differential equations (SPDEs) is based on separation of variables using the Cameron-Martin construction of the orthonormal basis in the space of square integrable functionals of the Wiener process. In particular, this Wiener Chaos approach makes it possible to improve various classical regularity results for SPDEs and to establish new ones. I will outline the main ideas of the Wiener Chaos approach and illustrate the approach on the equation describing time evolution of a passive scalar in the incompressible turbulent velocity field under the Kraichan’s model.

The Kraichan’s model of turbulent transport can be reduced to a stochastic partial differential equation in the Stratonovich sense:

$$d\theta(t, x) + \sum_{i,k} \sigma^i_k(x) \frac{\partial \theta(t, x)}{\partial x^i} \circ dw_k = 0, \quad t > 0, \quad \theta(0, x) = \theta_0(x);$$

(1)

mathematically, turbulence means that the functions $\sigma^i_k$ are not Lipschitz continuous. As a result, the corresponding flow equation does not have a unique solution, and the traditional analysis by the method of characteristics cannot provide adequate information about the solution of (1).

We construct a solution of (1) using Wiener chaos expansion of $\theta$. The main result is that, for every $\theta_0 \in L_2(\mathbb{R}^d)$, there exits a unique random field $\theta = \theta(t, \cdot) \in L_2(\mathbb{R}^d)$, $t > 0$, with the following properties:

- For every smooth compactly supported function $\varphi$,
  $$\langle \theta(t), \varphi \rangle = \langle \theta_0, \varphi \rangle + \sum_{i,k} \int_0^t \left( \theta(s), \sigma^i_k \frac{\partial \varphi}{\partial x^i} \right) \circ dw_k(s)$$
  (2)

  with probability one, where $\langle \cdot, \cdot \rangle$ denotes the inner product in $L_2(\mathbb{R}^d)$.

- The coefficients of the Wiener chaos expansion of $\theta$ satisfy a lower-triangular system of deterministic parabolic equations and provide a convenient way of approximating both the individual realizations and statistical moments of $\theta$.

- For every $t > 0$, $E\|\theta(t, \cdot)\|_p^{L_\infty(\mathbb{R}^d)} \leq \|\theta_0\|_{L^p(\mathbb{R}^d)}$, $2 \leq p < \infty$.

- If $X_{t,x}(s)$ is a weak solution of the backward Itô equation
  $$X^i_{t,x} (s) = x^i - \int_s^t \sum_{k \geq 1} \sigma^i_k (X_{t,x} (r)) \overline{dw}_k (r),$$
  then
  $$\theta(t, x) = E \left( \theta_0 (X_{t,x} (0)) | \mathcal{F}^W_t \right).$$

(4)
Finite Horizon Ruin Probability Computation for Heavy Tailed Distributions Through Corrected Diffusion Approximation

YINGDONG LU(speaker)

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We approximate finite horizon ruin probability of general random walks with heavy tail increment through corrected diffusion approximations. We extend the methodology used in M. Hogan[1] to the case of finite horizon. Replacing the fixed time epoch, we will use a Poisson process with rate 1 as a random clock, thus reduce the problem to finding the ruin probability to a two dimensional random walk. Conducted the similar Fourier analysis as those in [1], we are able to get the approximation in explicit forms.

We consider the problem of optimal switching with finite horizon. This special case of stochastic impulse control naturally arises during analysis of operational flexibility of exotic energy derivatives. We propose a new method of numerical solution based on recursive optimal stopping. The key tool employed is approximation of the Snell envelopes by simultaneous Monte Carlo regressions using the ideas of [1]. This can also be seen as a new numerical scheme for reflected backward stochastic differential equations. Convergence analysis is carried out and numerical results are illustrated with a variety of concrete examples. We furthermore investigate extensions to tackle other energy contracts, such as gas storage, exhaustible resources and power supply guarantees. Our approach is robust and avoids the ad hoc aspects of quasi-variational inequalities.

Optimal Portfolio Selection Strategies in the Presence of Transaction Costs

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Ananda Weerasinghe

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We consider an investor who has available a bank account (risk free asset) and a stock (risky asset). It is assumed that the interest rate for the risk free asset is zero and the stock price is modeled by a diffusion process. The wealth can be transferred between the two assets under a proportional transaction cost. Investor is allowed to obtain loans from the bank and also to short-sell the risky asset when necessary. The optimization problem addressed here is to maximize the probability of reaching a financial goal $a$ before bankruptcy and to obtain an optimal portfolio selection policy. Our optimal policy is a combination of local-time processes and jumps. In the interesting case, it is determined by a non-linear switching curve on the state space. This work is a generalization of [1], where this switching boundary is a vertical line segment.

We tackle the problem of how to compute risk measures for derivatives securities on general Markov diffusion processes and analyse situations on when it is possible to have analytically tractable solutions. We specialise our analysis in the risk measures Worst-Case Scenarios (WCS), Value-at-risk (VaR) and Conditional Value-at-Risk (CVaR) but results may apply directly to other risk measures. In the European derivatives case, our method focuses into formulate the problem as a PDE system with terminal conditions. For some derivatives, it turn out that this PDE has degeneracy points and the problem becomes a moving boundary PDE with terminal conditions. We show how to solve the latter problem and illustrate with some examples.

On uniqueness for stochastic heat equations with non-Lipschitz coefficients

LEONID MYTNIK(speaker)

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We consider the question of uniqueness of solution to stochastic partial differential equations (SPDEs). We focus on the case of a particular parabolic SPDE — the heat equation perturbed by a multiplicative noise, or the stochastic heat equation.

Two important types of uniqueness are discussed: pathwise uniqueness and uniqueness in probability law of the solution. Under Lipschitz assumptions on noise coefficients, the pathwise uniqueness for a large class of SPDEs has been known for a long time. For non-Lipschitz SPDEs, uniqueness in law has been known in some very specific cases.

We describe results of joint work with Edwin Perkins and Anja Sturm on pathwise uniqueness for the stochastic heat equation

\[ \frac{\partial}{\partial t} u(t, x) = \frac{1}{2} \Delta u(t, x) dt + \sigma(u(t, x)) \dot{W}(x, t), \quad t \geq 0, \quad x \in \mathbb{R}^d \]

driven by Gaussian noise \( \dot{W} \) on \( \mathbb{R}^d \times \mathbb{R}_+ \). \( \dot{W} \) is white in time and "colored" in space. The case of non-Lipschitz coefficients \( \sigma \) and singular spatial noise correlations is considered.
Ant Networks

SERBAN NACU (speaker)

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Ants are very succesful creatures; it is estimated they make up at least 10% of the terrestrial animal biomass. Ant colonies are capable of complex and robust behavior; yet individual ants perform fairly simple tasks. Colony behavior is achieved without central control. Information is transmitted across the colony by interactions among ants, and the behavior of individual ants is strongly influenced by these interactions.

We discuss a series of experiments performed on a population of harvester ants living in the Arizona desert, that illustrate some of these points. Their analysis raises some interesting statistical and mathematical questions. We also mention some problems in (pure) probability theory that were inspired by the ants. No previous knowledge of ants will be assumed.

This is joint work with Deborah Gordon and Susan Holmes.
On the distribution of the maximum of a smooth Gaussian field

Yuval Nardi (speaker)

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Using a probabilistic method involving a change of measure, we give an asymptotic expansion for the probability that the maximum of a Gaussian random field exceeds a high threshold. The form of the expansion, which involves the standard normal density multiplied by a polynomial in the threshold with coefficients that involve integrals over the parameter set of partial derivatives of the covariance function, is compared with results obtained by geometric methods, which until recently did not have a rigorous mathematical basis.
Decomposition of Motor Unit Firing Pattern with Kalman Filtering

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Interdischarge interval (IDI) is one of the basic parameters of motor unit firing analysis. Discharge intervals of a single motor unit do vary over time and they are unpredictable. In previous studies, IDI sequences have been considered as the summation of two major components: an IDI trend and an instantaneous firing variability (IFV). In this study, we present a new method to decompose motor unit firing pattern into these components using state space modeling and Kalman Filter.
Impulsive Control of Portfolios

Jan Palczewski (speaker)

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Lukasz Stettner

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In the talk a general model of a market with asset prices and economical factors of Markovian structure is considered (see [2]). The problem is to find optimal portfolio strategies maximizing a discounted infinite horizon utility functional i.e.

\[ E \int_0^\infty e^{-\alpha t} F(N(t), S(t)) dt \rightarrow \max, \]

where \( S(t) \in ]0, \infty[^d \) denotes asset prices, \( N(t) \in \mathbb{R}_+^d \) denotes portfolio contents, \( \alpha > 0 \) is a discount rate and \( F \) is an evaluation function. There are general transaction costs which, in particular, cover fixed plus proportional costs. It is shown, under general conditions, that there exists an optimal impulse strategy and the value function is a solution to a suitable Bellman equation. It is not required that \( F \) be a bounded function. Several examples are provided. They cover most of the Markovian models presented in the literature.

One can see that there is a remarkable difference between classical optimal impulsive control problems (see [1]) and the one considered here. Namely, costs of the impulses do not appear as a penalizing term in the reward functional; they are encoded in the set of available controls. This type of problems is present in the literature. In [3] and [4] authors considered a model without economic factors and manage to prove existence of optimal control in special cases. Economic factors are dealt with in [2]. A common trait of these papers is the approach based on quasi-variational inequalities, introduced in [1]. Here, however, techniques based on fixed point theorems are employed allowing for greater generality.

To accurately simulate a multiscale system, one has to simulate it in its micro time-scale. This can be very inefficient. The “projective integration” or “heterogeneous multiscale” methods take advantage of the averaging principle satisfied by the system in order to build more efficient algorithms (for a review of the recent literature on these methods see [1]). In the case of a multiscale diffusion of the form

\[
\begin{aligned}
dX_t^\epsilon &= f(X_t^\epsilon, Y_t^\epsilon)dt \\
dY_t^\epsilon &= \frac{1}{\epsilon} g(X_t^\epsilon, Y_t^\epsilon)dt + \frac{1}{\sqrt{\epsilon}} \sigma(X_t^\epsilon, Y_t^\epsilon)dW_t,
\end{aligned}
\]

the heterogeneous multiscale method has been analyzed in [2]. The main idea is to simulate the fast variable \( Y \) on a micro time-scale, while keeping the slow variable \( X \) fixed. Once we have the invariant distribution of the fast variable, we use the averaging principle to approximate the evolution of the slow variable by an ODE. We numerically solve the ODE in order to get an estimate of the value of the slow variable at the next macro time-step. We do the same for the new value of \( X \).

We will extend this method to the case where the simulations are done in a “black box”: we do not have any knowledge of the drift \( f \) and \( g \) or the variance \( \sigma \), we do not have any control over the simulations other than choosing the initial conditions and we cannot simulate each of the components separately.

We will also present ways to improve the original algorithm. We will show how to improve the initialization of the distribution of the fast scale, using the knowledge of the invariant measure at the previous macro time-steps. Finally, we will discuss methods for reducing the variance. Since the simulations are done in a “black box”, we cannot use any importance sampling techniques. Assuming that we know exactly the invariant measure for \( t = 0 \), we take advantage of the slow evolution of the invariant measure and we use the simulations of the previous time-steps as control variates. If at different macro time-steps, the simulations of the fast variable correspond to the same random seed, then the correlation between simulated paths at different macro time-steps will actually be very close to one.


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**Abstract 70**

**Simulating Multiscale Systems.**

**Anastasia Papavasiliou** (speaker)

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Consider the standard Wiener space $\Omega$ with its (one-dimensional) Wiener process $W_t$. It is well known that any integrable variable $F$ defined on this space can be written as a stochastic integral

$$F = E[F] + \int_0^\infty Z_t dW_t$$

for a predictable process $Z_t$. The problem of expressing $Z_t$ in terms of $F$ has been studied for a long time, and in particular, it is known that $Z_t$ is the predictable projection of the Malliavin derivative $D_tF$ of $F$ (Clark-Ocone formula).

In this work, we consider another expression for $Z_t$ which does not require any differentiability in the sense of Malliavin, but which relies on the analysis of Brownian excursions above or below any level. More precisely, we prove that $Z_t$ is the predictable projection of

$$D_tF = \int_{\Theta} (F \circ \mathcal{E}_{t,\theta}^+ - F \circ \mathcal{E}_{t,\theta}^-) \mathcal{I}(d\theta),$$

where $\Theta$ is the space of positive excursions, $\mathcal{I}$ is the Itô measure on $\Theta$, $\theta^*$ is the negative excursion deduced from $\theta$ by reflection, and $\mathcal{E}_{t,\theta}^+$ is the transform of $\Omega$ which inserts the excursion $\theta$ at time $t$.

One can also define the transform $\mathcal{E}_{t,\theta}^-$ which removes the excursion beginning at time $t$, and the operator $D_t$ can be studied by means of a calculus involving $\mathcal{E}_{t,\theta}^+$ and $\mathcal{E}_{t,\theta}^-$ (this calculus is similar to the calculus appending and removing masses to a Poisson measure of [1]). In particular, one can consider the adjoint $D^*$ which is (like the Skorohod integral in Malliavin’s calculus) an extension of the Itô integral. Actually, this excursion calculus is strongly related to some random $\sigma$-finite measures on $R_+$ which give mass to times $t$ at which an excursion of $W$ begins or ends (these measures are also related to the tree representation of the Wiener path).

Another application of this calculus is to provide new constructions of stochastic integrals. These constructions rely on the above-mentioned $\sigma$-finite measures and give an insight about the difference between Itô and Stratonovich integrals. Anticipating integrals can also be considered.

Estimations of the parameters of the Smoothly Truncated Lévy distributions and their applications to EEG-sleep patterns of neonates

ALEXANDRA PIRYATINSKA (speaker)

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The class of Smoothly Truncated Lévy (STL_α) distributions ([1]) is an intermediate class of distributions between α-stable and normal distributions with characteristic function

\[ \psi_X(u) = \exp\left(-\left(\lambda^\alpha [q\zeta_\alpha(-u/\lambda) + p\zeta_\alpha(u/\lambda)] + i\lambda^b\right)ight) \]

\[ \zeta_\alpha(r) = \begin{cases} 
\Gamma(-\alpha) [(1-ir)^\alpha - 1], & 0 < \alpha < 1; \\
(1-ir) \log(1-ir) + ir, & \alpha = 1; \\
\Gamma(-\alpha) [(1-ir)^\alpha - 1 + i\alpha r], & \text{for} \quad 1 < \alpha < 2. 
\end{cases} \]

where \( a, p, q \geq 0, p + q = 1, b \) is a real number.

The MM and Numerical MLE parametric estimation tools for these distributions are developed. The results are verified by simulations.

The above methods are applied to a study of the recordings of EEG sleep signals for fullterm and preterm neonates. Neurophysiologists have traditionally identified, by visual analysis of the EEG, four distinct encephalogram patterns during sleep. Therefore the EEG data are not stationary. Our first problem is to separate the time series into quasi-stationary increments. For this purpose we use the Hausdorff fractional dimension (see [2]) and change point detection algorithm for the change in the mean ([3]). For the homogeneous increments the numerical MLE for smoothly truncated Lévy distribution is performed. The conclusion is that the STL model is appropriate for EEG-sleep patterns of fullterm babies.

The resulting negative binomial process is a purely jump, non-decreasing process with general negative binomial marginal distributions. The joint distribution of the arrival times and (integer valued) jumps is obtained from its representation as a compound Poisson process. The distribution of arrival times of jumps is parameter free, when conditioned on values at integer arguments. These distributions can be effectively used to generate sample paths. Subordination of a negative binomial process to another independent one leads again to a negative binomial process and subordination becomes a group operation within this class of processes. There are interesting relations between negative binomial and gamma processes. For example, the negative binomial process can be equivalently defined as a Poisson process subordinated to a gamma process and thus is also known in the literature as the gamma-Poisson process. Moreover, the gamma process is scale invariant with respect to subordination to the negative binomial process – the property defined as geometric self-similarity. The gamma process can be also obtained as a limit of scaled negative binomial processes when the probability of a success is diminishing to zero.

The Fluid Limit of an Overloaded Processor Sharing Queue

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The topic of this talk is strictly supercritical fluid models which arise as functional law of large numbers approximations for overloaded processor sharing queues. Analogous results for critical fluid models associated with heavily loaded processor sharing queues are contained in Gromoll et al. [1] and Puha & Williams [3]. As in those earlier works, we use measure valued processes to describe overloaded processor sharing queues. An important distinction between critical fluid models and strictly supercritical fluid models is that the total mass for a fluid model solution that starts from zero grows with time for the latter, but it is identically equal to zero for the former. The talk will contain a description of the distribution of the mass as it builds up from zero. Also, the set of stationary fluid model solutions (solutions for which the shape does not change with time) will be identified. In addition, the shape of any fluid model solution will be shown to converge to an invariant shape as time tends to infinity. Finally, a fluid limit result will be stated that justifies strictly supercritical fluid models as first order approximations to overloaded processor sharing queues.

The Random Average Process and Random Walk in a Space-Time Random Environment in One Dimension

Firas Rassoul-Agha (speaker)

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It has been recently discovered that in some classes of one-dimensional asymmetric interacting systems the random evolution produces fluctuations of smaller order than the natural diffusive scale. Two types of such phenomena have been noted.

In Hammersley’s process, in asymmetric exclusion, and in some other closely related systems, dynamical fluctuations occur on the scale $t^{1/3}$. Currently known rigorous results suggest that the Tracy-Widom distributions from random matrix theory are the universal limits of these fluctuations. The first rigorous results in this vein are due to Baik, Deift, and Johansson (1999).

The second type of result has fluctuations of the order $t^{1/4}$ and limits described by a family of self-similar Gaussian processes that includes fractional Brownian motion with Hurst parameter $1/4$. The first result of this type was proved for a system of independent random walks by Seppäläinen (2005).

We show that the $t^{1/4}$ fluctuations also appear in a family of interacting systems called random average processes in one dimension. The same family of limiting Gaussian processes appears here too, suggesting that these limits are universal for some class of interacting systems. Partial results dealing with one-time marginals have been shown by Ferrari and Fontes (1998).

To be able to prove the above result, we utilize a dual description in terms of certain random walks in space-time random environments. Our investigation also leads to quenched invariance principles for the random walk itself (scale $n^{1/2}$), as well as for the quenched mean process (scale $n^{1/4}$). Partial results dealing with one-time marginals have been shown by Boldrighini et al. (1997-2004).
The Entropy Rate of the Hidden Markov Process

MOHAMMAD REZAEIAN (speaker)

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A stochastic process which is a noisy observation of a Markov process through a memoryless channel is called a hidden Markov process (HMP). Finding the entropy rate of HMP is motivated by applications in both stochastic signal processing and information theory. The first expression for the entropy rate of HMP is found in 1957 [1]. This expression is defined through a measure described by an integral equation which is hard to extract from the equation in any explicit way. Besides a known upper bound on the entropy rate for the general case, simple expressions for the entropy rate has been recently obtained for special cases where the parameters of hidden Markov source approaches zero [2],[3].

In contrast to [1], the formula for the entropy rate of HMP presented in this paper is expressed by a measure which is the stationary distribution of a Markov process, hence it can be computed by iterative numerical methods. Using the results on Partially Observed Markov Decision Processes [4], we show that the past history of a HMP can be sufficiently described by the information-state process, a continuous state Markov process, and the entropy rate of the HMP is the expectation of a related function under the stationary distribution of this process.

A Hidden Markov Process \( \{Z_n\}_{n=0}^{\infty} \) is defined by a quadruple \( [S, P, Z, T] \), where \( S, P \) are the state set and transition probability matrix of a Markov process and \( Z, T \) is the observation set and the observation probability Matrix \( |S| \times |Z| \), respectively. By defining the random variable \( q_n(Z^{n-1}) \) over the \( |Z| \)-dimensional probability simplex (denoted by \( \nabla Z \)) with components \( q_n[k] = Pr(Z_n = k | Z^{n-1}) \), we show that the entropy rate is \( \hat{H}(Z) = \lim_{n \to \infty} E[h(q_n)] \), where \( h(.) \) is the entropy function over \( \nabla Z \). Since \( \{q_n\}_{n=0}^{\infty} \) is not a Markov process, the measure for evaluating this expectation is not computable. However if we consider the information-state process \( \{\pi_n\}_{n=0}^{\infty} \), which is related to \( \{q_n\}_{n=0}^{\infty} \) by the transformation \( q_n = q(\pi_n) = \pi_n \times T \), the entropy rate can be formulated as

\[
\hat{H}(Z) = \int_{\nabla S} h(q(\pi')) \mu(d\pi'),
\]

where \( \mu(.) \) is the stationary distribution of information-state process, and it can be computed by the fact that this process is Markov with the transition probabilities defined explicitly by \( P \) and \( T \). The application of this entropy rate formula results in a formulation of Shannon capacity for finite state symmetric Markov channels identical to previous results.

Consider a $n \times n$ matrix $M$ comprised of independent identically distributed complex random variables of mean zero and mean-square one. We prove a central limit theorem for linear functionals of the eigenvalues of $(1/\sqrt{n})M$ as $n \to \infty$. Technicalities currently require the analyticity of the functional in addition to more expected moment restrictions on the entries of $M$. If $M$ happens to be Gaussian, or drawn from the Ginibre ensemble, we describe a more rapid proof of a sharper result. The latter rests on the orthogonality of a class of special functions evaluated at the Ginibre eigenvalues.
Hitting distributions of geometric Brownian motion

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Let $\tau$ be the first hitting time of the point 1 by the geometric Brownian motion $X(t) = x \exp(B(t) - 2\mu t)$ with drift $\mu \geq 0$ starting from $x > 1$. Here $B(t)$ is the Brownian motion starting from 0 with $E^0B^2(t) = 2t$. We provide an integral formula for the density function of the stopped exponential functional $A(\tau) = \int_0^\tau X^2(t)dt$ and determine its asymptotic behaviour at infinity. As a corollary we provide an integral formula and give asymptotic behaviour at infinity of the Poisson kernel for half-spaces for Brownian motion with drift in real hyperbolic spaces of arbitrary dimension.
Integral functionals, occupation times and hitting times of diffusions

Salminen Paavo (speaker)

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In this talk several known and some new identities between integral functionals, occupation times and hitting times of diffusions and, especially, Brownian motion are discussed. As an example (due to Dufresne and Yor) consider

\[ \int_0^\infty \exp(-2B_s^{(\mu)}) \, ds \overset{(d)}{=} H_0(R^{(\delta)}) \]

where \( B^{(\mu)} \) is a Brownian motion with drift \( \mu > 0 \) started from 0, \( R^{(\delta)} \) is a Bessel process of dimension \( \delta = 2(1 - \mu) \) started from 1, and

\[ H_0(R^{(\delta)}) = \inf\{ s > 0 : R_s^{(\delta)} = 0 \} . \]

Another example (due to Biane and Imhof) is

\[ \int_0^\infty 1_{\{B_s^{(\mu)} < 0\}} \, ds \overset{(d)}{=} H_\lambda(B^{(\mu)}) \]

where \( B^{(\mu)} \) is as above and \( \lambda \) is an exponentially distributed random variable independent of \( B^{(\mu)} \).

It is well known that the Feynman-Kac formula is a very powerful tool to compute the distributions of functionals of linear diffusions but this formula does not usually explain identities between different functionals. However, in many cases such identities can be better understood using random time change and Ray-Knight theorems, as is demonstrated in this talk which is based on the following papers:

Small perturbations of rough paths of fractional Brownian motion

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Rough path analysis is a mathematical theory developed by Lyons in [3] providing a pathwise approach to stochastic differential equations. In [1], the rough path lying above a fractional Brownian motion (FBM) with Hurst parameter $H \in \left(\frac{1}{4}, \frac{1}{2}\right)$, $W^H$, is constructed as an element of the space of geometric rough paths $D_p$, for any $p \in \left[1, \frac{4}{3}\right]$ with $Hp > 1$. Using Lyons theory, FBM can be used as control for differential equations and their solutions are continuous functionals of the enhanced FBM in the $p$–variation distance.

We study small perturbations of such systems driven by FBM. Because of the continuity mentioned before, this amounts to state large deviation estimates for the rough path associated with a FBM. Our main result reads as follows.

**Theorem** The family $(F(\epsilon W^H), \epsilon > 0)$ of perturbed rough paths based on $W^H$, satisfies a large deviation principle in $D_p$ with good rate function

$$\mathcal{I}(X) = \frac{1}{2} \|i^{-1}(X^1_{0,})\|_{\mathcal{H}}^2$$

if $X^1_{0,} \in i(\mathcal{H})$ and $\mathcal{I}(X) = \infty$, otherwise.

In (1), $\mathcal{H}$ denotes the the reproducing kernel Hilbert space associated with the FBM and $i$ the embedding of $\mathcal{H}$ into $D_p$.

The results extend the classical ones for Gaussian processes and those proved by Ledoux et al. in [2] for the Brownian motion. As a by-product, we obtain the existence of a geometric rough path lying above an element of $\mathcal{H}$. This problem is related with the construction of multiple deterministic Volterra integrals

Anomalous mobility of Brownian particles in a tilted symmetric sawtooth potential

AKO SAUGA(speaker)

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We consider one-dimensional overdamped dynamical systems, where Brownian particles move in a spatially periodic piecewise linear symmetric potential $V$, which has one minimum per period. The applied force consists of an additive static force $F$ and a noise term composed of thermal noise $\xi$ and a colored three-level Markovian noise. The system is described by the stochastic differential equation

$$\kappa \frac{dX}{dt} = -\frac{dV(X)}{dX} + F + \xi(t) + fZ(X, t),$$

where $\kappa$ is the friction coefficient, $f$ is a constant force, and $Z(X, t)$ represents spatially non-homogeneous fluctuations assumed to be a Markovian stochastic process taking the values $z_n \in \{-1, 0, 1\}$.

On the basis of an exact expression for the current we have found a number of cooperation effects: (i) a resonant-like behavior of absolute negative mobility (ANM) at intermediate values of the switching rate; the presence and intensity of ANM can be controlled by the switching rate and by temperature, (ii) existence of a negative differential resistance, (iii) for large values of the switching rate and a low temperature the current is, at some values of the tilting force $F$, very sensitive to a small variation of $F$ — a phenomenon called hypersensitive differential response (HDR), and in the region of HDR the value of differential mobility can be controlled by means of thermal noise; (iv) for certain system parameters, there is a finite interval of the tilting force where the current is very small as compared to that in the surroundings (the effect of “disjunct windows”). It seems that the behavior mentioned last is a new anomalous transport phenomenon for Brownian particles.

The phenomenon of ANM in systems similar to ours have been studied in [1]. However, in contrast to ours, in those models the authors choose a symmetric potential $V(x)$ with two minima per period. Perhaps the most fundamental difference is that in the models of [1] unbiased transitions can take place between the discrete states only at the minima of potentials. As a consequence the dependence of the current on the switching rate disappears.

We emphasize that to our knowledge such a rich variety of anomalous transport effects have never been reported before for an overdamped Brownian particle in a 1D periodic structure with a simple symmetric potential (with one minimum per period).

Improving on bold play when the gambler is restricted

JASON SCHWEINSBERG (speaker)

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Suppose a gambler starts with a fortune in (0,1) and wishes to attain a fortune of 1 by making a sequence of bets. Assume that whenever the gambler stakes the amount $s$, the gambler’s fortune increases by $s$ with probability $w$ and decreases by $s$ with probability $1 - w$, where $w < 1/2$. Dubins and Savage showed that the optimal strategy, which they called “bold play”, is always to bet $\min\{f, 1 - f\}$, where $f$ is the gambler’s current fortune. Here we consider the problem in which the gambler can stake no more than $\ell$ at one time. We show that the bold strategy of always betting $\min\{\ell, f, 1 - f\}$ is not optimal if $\ell$ is irrational, extending a result of Heath, Pruitt, and Sudderth.
Cooperative sequential adsorption and related sequential Markov point processes

V. Shcherbakov (speaker)

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Mathematical models such as cooperative sequential adsorption are widely used in physics and chemistry for modelling of chemisorption on single-crystal surfaces, adsorption in colloidal systems and other similar processes in physics and chemistry ([1]). The main peculiarity of these processes is that adsorbed particles (molecules) change adsorption rates in the space around their locations. Motivated by these models we define a new Markov point process. The process state cannot be represented by an "unordered set of points" as it was in the classical theory of Markov point processes. The process states are random vectors, i.e. ordered sets of points, it is a sequential Markov point process ([2]). We present a systematic study of the process, which includes investigation of its Markov properties, convergence of Markov Chain Monte Carlo samplers ([2]) and statistical inference. We prove that in important for simulation cases the process is locally stable and local stability holds with bound which, as we show, cannot be in general improved. Statistical inference includes studying of asymptotic properties of the model statistics (as an observation window expands infinitely) and parameter estimation based on maximum likelihood approach. Using computer simulations we show that the proposed sequential Markov point process can be used for modelling both repulsive and attractive effects in sequential patterns.

The results are based on joint work with M.N.M. van Lieshout.

A super-stable motion with infinite mean branching

Anja Sturm (speaker)

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Klaus Fleischmann

A class of finite measure-valued cadlag superprocesses $X$ with Neveu’s (1992) continuous state branching mechanism is constructed. To this end, we start from certain supercritical $(\alpha,d,\beta)$-superprocesses with symmetric alpha-stable motion and $(1+\beta)$-branching and prove convergence on path space as $\beta$ tends to 0. The log-Laplace equation related to $X$ has the locally non-Lipschitz function $u \log u$ as non-linear term, and it is shown to be well-posed. We will describe some interesting properties of the resulting process: $X$ has infinite expectation, is immortal in all finite times, propagates mass instantaneously everywhere in space, and has locally countably infinite biodiversity.
Abstract 85  
Session A4

Weak Convergence Of The Median Of Independent Brownian Motions

Jason Swanson (speaker)

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In a model of Spitzer (1968), we begin with countably many particles distributed on the real line according to a Poisson distribution. Each particle then begins moving with a random velocity; these velocities are independent and have mean zero. The particles interact through elastic collisions: when particles meet, they exchange trajectories. We then choose a particular particle (the tagged particle) and let $X(t)$ denote its trajectory. Spitzer showed that, under a suitable rescaling of time and space, $X(t)$ converges weakly to Brownian motion.

Harris (1965) demonstrated a similar result: if the individual particles move according to Brownian motion, then $X(t)$ converges to fractional Brownian motion. These results were generalized even further by Dürr, Goldstein, and Lebowitz in 1985.

All of these results rely heavily on the initial distribution of the particles. The initial Poisson distribution provides tractable computations in the models of Spitzer, Harris, and Dürr et al.

In this talk, I will outline the following result: the (scaled) median of independent Brownian motions converges to a centered Gaussian process whose covariance function can be written down explicitly. As with the other results, proving tightness is the chief difficulty. Unlike the other results, the initial distribution of the particles does not play a key role. Tightness is proved in this model by direct estimates on the median process itself. It is my hope that these techniques can be generalized and used to extend the current family of results to models with arbitrary initial particle distributions.
Abstract 86
Invited Lecture

**Random motions in random media**

**Alain-Sol Sznitman** (speaker)

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The mathematical analysis of models of particles moving randomly in disordered environments has been very active over the last thirty years. It has uncovered a number of surprising effects that ran contrary to the prevailing intuition. New paradigms and mathematical challenges have emerged. In this lecture we will discuss some of these surprising effects and report on some of the progresses that have been made.
Critical values of smooth random fields

JONATHAN TAYLOR (speaker)

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We discuss the generic behaviour of the critical points / values of smooth Gaussian random fields on smooth manifolds $f : M \to \mathbb{R}$, which we think of as point processes on the parameter space of the field (the critical points) with real-valued marks (the critical values).

For parameter spaces of a fixed dimension, these marked point processes can be combined with some tools from differential topology to derive an accurate approximation to the supremum distribution

$$\mathbb{P} \left\{ \sup_{x \in M} f(x) \geq u \right\}$$

based on the geometry of the excursion sets

$$\{x \in M : f(x) \geq u\},$$

specifically the expected Euler characteristic of the excursion sets.

In general, the accuracy of the above expression is poorly understood if we allow the dimension of $M$ to grow. In this work, we investigate some aspects of the accuracy in the high dimensional setting, restricting attention to isotropic process on $[0, 1]^n$ with $n$ growing. In this situation, the “spectrum” of critical values behave in some sense like the eigenvalues of a large GOE (Gaussian Orthogonal Ensemble) matrix at the bulk and the edge.

We identify two separate regimes for the behaviour of the mean spectral measure of the critical values of smooth isotropic Gaussian fields in high dimensions. Understanding the limiting behaviour of the mean spectral measure depends on a characterization of the covariance functions of isotropic processes in high dimensions.

We discuss some of the many open questions involving the behaviour of the critical values of smooth random fields in high dimensions, which we consider to be generalizations of the eigenvalues of large random matrices.
We study a unifying framework, introduced by Durrleman [2], for modeling the dynamics of the implied volatility surface of a stock. This framework is analogous to the Heath, Jarrow, and Morton [3] and Musiela [4] approach to modeling the term structure of interest rates. In particular, we study the issue of hedging exotic options with portfolios consisting of the underlying stock as well as European options on that stock.

The Henstock approach to Multiple Stochastic Integrals

TOH TIN-LAM (speaker)

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The classical Riemann approach has been well-known for its explicitness and intuitive approach to the theory of integration. However, the integrators are functions of bounded variation. Thus, it is often stated in the literature that it is difficult to define stochastic integrals using the Riemann approach. Riemann’s theory of integration is unable to handle functions that are highly oscillating.

However, with a slight modification by the use of non-uniform mesh, the Riemann approach (now called the generalized Riemann approach or Henstock approach) is able to handle more functions. Now, the constant mesh $\delta$ is replaced by a positive function $\delta(\xi) > 0$ for each $\xi$ on the domain of the function. It turns out that in the theory of the non-stochastic integrals, this generalized Riemann integral can handle many more functions that the classical Riemann integral fails to handle.

It has further been shown that for the stochastic integration theory, the generalized Riemann approach is able to give an equivalent definition of the classical stochastic integrals with the integrator as a semi-martingale, see [1], [2] and [3]. Furthermore, many properties of stochastic integrals have been easily proved.

In this paper, we shall show that the generalized Riemann approach can give an equivalent definition of the Multiple Stochastic Integral, and give an alternative derivation to the Hu-Meyer Theorem.

Approximate and perfect simulation of spatial Hawkes processes

GIOVANNI LUCA TORRISI (speaker)

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JESPER MØLLER

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We discuss how the spatial version of classical Hawkes processes can be simulated. A straightforward but approximate simulation algorithm suffers from edge effects. We quantify these edge effects and describe an alternative perfect simulation algorithm. The algorithms extend those for classical Hawkes processes in a nontrivial way. Our results are exemplified for Gaussian fertility rates. We discuss possible extensions.

I will present two recent results in the context of the title.

(1) The most robust relative entropy method (see [4]) is widely applied for deriving hydrodynamic limits (hdl) of interacting particle systems in the regime of smooth solutions of the limiting PDEs. Hence it is not applicable for deriving hdl beyond the appearance of shock discontinuities in hyperbolic systems. The general method applied in [5] is based on a coupling argument and works for so-called attractive one-component systems only. In [1] a stochastic version of the method of compensated compactness (originally developed in the context of viscous approximation hyperbolic PDEs) was proposed. This method was successfully applied in [2] for a two component hyperbolic system of interacting particles, proving for the first time validity of the hdl beyond the appearance of shocks for a non-attractive system with more than one conservation laws. This is still a rather special result valid for a particular model only. More robust extensions are being developed in [3].

(2) Propagation of small perturbations of particular (singular, non-hyperbolically degenerate) steady states of two component hyperbolic systems are described by a universal hydrodynamic limit leading to the hyperbolic system of conservation laws

\[
\begin{align*}
\partial_t \rho + \partial_x (\rho u) &= 0 \\
\partial_t u + \partial_x (\rho + \gamma u^2) &= 0,
\end{align*}
\]

where \( \gamma > 1 \) is a constant parameter reflecting some feature of the interacting particle system. In [6] we prove this universal hdl, valid in the smooth regime of solutions. The method of proof is a mixture of refined pde and probabilistic techniques.

In this talk we explain how the moving average and series representations of fractional Brownian motion can be obtained using the spectral theory of vibrating strings. The representations are shown to be consequences of general theorems valid for a large class of second order processes with stationary increments. Specifically, we use the 1-1 relation discovered by M.G. Krein between spectral measures of continuous second order processes with stationary increments and differential equations describing the vibrations of a string with a certain length and mass distribution.
Crash Options, Rally Options

JAN VECER (speaker)

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In this talk, we introduce new types of options which do not yet exist in the market with some very desirable features. These proposed contracts can directly insure events such as a market crash or a market rally. Although the currently traded options can to some extent address situations of extreme market movements, there is no contract whose payoff would be directly linked to the market crash and priced and hedged accordingly as an option.

We investigate these contracts in geometric Brownian motion model, give analytical characterization of their price and hedge, and link them with the existing techniques in change point detection (CUSUM).

The Disk-Covering Method for Phylogenetic Tree Reconstruction

TANDY WARNOW (speaker)

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Phylogenetic trees, also known as evolutionary trees, model the evolution of biological species or genes from a common ancestor. Most computational problems associated with phylogenetic tree reconstruction are very hard (specifically, they are NP-hard, and are practically hard, as real datasets can take years of analysis, without provably optimal solutions being found). Finding ways of speeding up the solutions to these problems is of major importance to systematic biologists. Other approaches take only polynomial time and have provable performance guarantees under Markov models of evolution; however, our recent work shows that the sequence lengths that suffice for these methods to be accurate with high probability grows exponentially in the diameter of the underlying tree.

In this talk, we will describe new dataset decomposition techniques, called the Disk-Covering Methods, for phylogenetic tree reconstruction. This basic algorithmic technique uses interesting graph theory, and can be used to reduce the sequence length requirement of polynomial time methods, so that polynomial length sequences suffice for accuracy with high probability (instead of exponential). We also use this technique to speed up the solution of NP-hard optimization problems, such as maximum likelihood and maximum parsimony.
A bounded variation control problem for diffusion processes

Ananda Weerasinghe (speaker)

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In this talk we consider an infinite horizon discounted cost minimization problem for a one dimensional stochastic differential equation model. The available control is an added bounded variation process. The cost structure involves a running cost function and a proportional cost for the use of the control process. The running cost function is not necessarily convex. We obtain sufficient conditions to guarantee the optimality of the zero control. Also, for unbounded cost functions, we provide sufficient conditions which make our optimal state process a reflecting diffusion on a compact interval. In both cases, the value function is a $C^2$ function. For bounded cost functions, under additional assumptions, we obtain an optimal strategy which turned out to be a mixture of jumps and local-time type processes. In this case, we show that the value function is only a $C^1$ function and that it fails to be a $C^2$ function. We also discuss a related variance control problem.
Abstract 96
Session B5

Poisson process approximation in Jackson networks

Aihua Xia (speaker)

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Melamed (1979) proved that for a Jackson network, a necessary and sufficient condition for the equilibrium flow along a link to be Poissonian is the absence of loops: no customer can travel along the link more than once. Barbour and Brown (1996) quantified the statement by allowing the customers a small probability of travelling along the link more than once and proved Poisson process approximation theorems analogous to Melamed’s Theorem. In this talk, we present a sharpened estimate of the approximation and talk about potential topics for further investigation.

Consider the family tree associated with a Galton-Watson branching process \( \{Z_n : n \geq 1; Z_0 = 1\} \). For any \( N = 1, 2, \ldots \) let \( T_N - 1 \) be the maximum height of a \( N \)-ary full (i.e., rooted in the ancestor) subtree; \( T_N = 0 \) if \( Z_1 < N \). The probability \( \tau_N = \lim_{n \to \infty} P(T_N > n) \) that a family tree contains an infinite \( N \)-ary full subtree was studied in detail in [3]. We introduce a random variable \( V_N \) as follows

\[
V_N = \text{number of full disjoint } N\text{-ary subtrees of a Galton-Watson family tree.}
\]

The distribution of \( V_N \) in terms of \( \tau_N \) and the offspring pgf \( f(s) \) is given below.

**Theorem** If \( N = 1, 2, \ldots \) then, for any \( j = 0, 1, \ldots \)

\[
P(V_N = j) = \sum_{k=0}^{N-1} \frac{\tau_{N+k}^j}{(jN+k)!} f^{(jN+k)}(1 - \tau_N),
\]

where \( \tau_N \) is the largest solution in \([0,1]\) of the equation \( 1 - t = G_N(1 - t) \), where \( G_N(s) = \sum_{j=0}^{N-1} (1 - s)^j f^{(j)}(s)/j! \).

The infinite \( N \)-ary full subtrees of a branching family tree admit some interesting interpretations. Assume that in a full \( N \)-ary subtree the offspring of a node are labelled from left to right using the alphabet \( \{0, 1, \ldots, N-1\} \). If the word \( (0, 1, \ldots, N-1) \) is repeated in the first \( n \) generations of the \( N \)-ary subtree, we say that it is seen by the root of the tree at height at least \( n \). Therefore, in an infinite family tree, \( V_N \) counts the number of ways the word \( (0, 1, \ldots, N-1) \) is seen by the root at infinite height. See also [1].

Problems of this nature appear in percolation theory. The authors of [3] point out a relationship between the model of \( N \)-ary full infinite subtrees and a construction employed in [2] in the study of Mandelbrot’s percolation processes. The existence of a \( N \)-ary subtree is also used in [4] in introducing the concept of a \( N \)-infinite branching process.

We illustrate the results on three special cases of offspring distributions: geometric, Poisson, and one-or-many.

Canonical forms for identifying aggregated markov models of single ion channel gating kinetics

JIN YANG(speaker)

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Deducing plausible reaction schemes from single-channel current trajectories is time-consuming and difficult. There are many ways to connect even a small number of states. Schemes which belong to an equivalent class make identical predictions. An exhaustive search over model space does not address the many equivalent schemes that will result. However, models can almost alway be linearly related into canonical topologies by similarity transformations. Besides a well-established canonical form ("uncoupled" form) [2], we have found a canonical form that can express all reaction schemes for binary aggregates (open/closed) of ion channel states [1]. This form has the minimal number of rate constants for any rank, which is referred to as the manifest interconductance rank (MIR) form because of the independence between interconductance transitions. By using the MIR and "uncoupled" forms we prove that all rank 1 topologies with a given number of open and closed states make identical predictions in steady state, thus narrowing the search space for simple models. We also show that fitting to canonical forms preserves detailed balance. Moreover, we propose an efficient hierarchical algorithm for searching for the simplest possible model consistent with a given data set.

Corrected random walk approximations to free boundary problems in optimal stopping

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Corrected random walk approximations to continuous-time optimal stopping boundaries for Brownian motion, first introduced in [1], [2] and [3], have provided powerful computational tools in option pricing and sequential analysis. We develop the theory of these second-order approximations by making use of renewal theory for random walks related to excess over the boundary and certain basic properties of the value functions of optimal stopping problems for Brownian motion.

Large time behavior of directed polymers in random environment

Nobuo Yoshida (speaker)

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Directed polymers in random environment can be thought of as a model of statistical mechanics in which paths of stochastic processes interact with a quenched disorder (impurities), depending on both time and space. We survey some results which have been obtained in recent years. The talk is based on joint works with Francis Comets and Tokuzo Shiga.
Central limit theorems for convex hulls and maximal points

JOSEPH E. YUKICH (speaker)

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Stabilization provides a useful tool in the asymptotic analysis of functionals of large random geometric structures, including random sequential packing models, random graphs, and percolation models. Here we use stabilization to describe variance asymptotics and central limit theorems for the number of vertices in the boundary of the convex hull of a multivariate i.i.d. sample as well as the number of maximal points in such samples. This represents joint work with Y. Baryshnikov, P. Calka, and T. Schreiber.
Martingale Approach to Stochastic Control with Discretionary Stopping

INGRID-MONA ZAMFIRESCU (speaker)

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We develop a martingale approach for continuous time stochastic control with discretionary stopping. The relevant Dynamic Programming Equation and the Maximum principle are developed. Necessary and sufficient conditions are provided for the optimality of a control strategy; these are the analogues of the “equalization” and “thriftiness” conditions developed by Dubins & Savage [3], in a related, discrete-time context. The existence of a thrifty control strategy is established.

Continuous Time Principal Agent Problems with Hidden Actions

JIANFENG ZHANG (speaker)

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In this talk we discuss the continuous time principal-agent problems with hidden actions in a very general framework. We use weak formulations for both the agent’s problem and the principal’s problem. We characterize the optimal contracts via solutions to some forward-backward SDEs, and establish a general sufficiency theorem. Some examples will also be presented.
Exit problems for reflected spectrally negative Lévy processes

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For a spectrally negative Lévy process $X$ on the real line, let $S$ be its supremum process and let $I$ be its infimum process. For $a > 0$ let $\tau(a)$ and $\kappa(a)$ be the times when the reflected processes $Z := S - X$ and $Y := X - I$ first exit level $a$ respectively. Our main results concern the distributions of $(\tau(a), S_{\tau(a)}, Z_{\tau(a)})$ and $(\kappa(a), Y_{\kappa(a)})$. They generalize those known results in [2] and [3] for Brownian motion. But our approach is different. It relies heavily on Bertoin’s results in [1] concerning the solution to the so-called two-sided exit problem for $X$. Such an approach can also be applied to study the excursions for the reflected processes.

Financial equilibria in the semimartingale setting: complete markets and markets with withdrawal constraints

GORDAN ŽITKOVIĆ (speaker)

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Existence of stochastic financial equilibria giving rise to semimartingale asset prices is established under a general class of assumptions. These equilibria are expressed in real terms and span complete markets or markets with withdrawal constraints. We deal with random endowment density streams which admit jumps and general time-dependent utility functions on which only regularity conditions are imposed. As an integral part of the proof of the main result, we establish a novel characterization of semimartingale functions.
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