

# Report on the STOCHASTIKA Workshop

Daniela Flimmel

8–12 February 2026

The STOCHASTIKA workshop was held at the Czech–Slovak border in the Javorníky Mountains at Hotel Kohútka. The scientific program focused on stochastic analysis, spatial statistics, and mathematical modelling in material science. The event was organized by

- Kateřina Helisová (FEL ČVUT)
- Viktor Beneš (KPMS MFF UK)
- Jakub Staněk (FEL ČVUT)
- Jiří Dvořák (KPMS MFF UK)
- Daniela Flimmel (KPMS MFF UK)

All organizers are members of COST Action CA24122 Working Group 4.

In total, the workshop hosted 22 participants, of whom 11 (50%) were COST Action members. The national distribution of participants was as follows: 17 from Czechia, 2 from Germany, and 1 each from Austria, Denmark, and Croatia. The workshop particularly supported early-career scientists, including 9 graduate students.

Each day consisted of two presentation sessions and one dedicated discussion session. These sessions proved highly productive, fostering scientific exchange and strengthening collaboration within the COST Action network. Participants actively engaged in methodological discussions, exchanged research ideas, and identified several topics suitable for joint research activities. The detailed program together with abstracts can be found at the workshop website here:

<https://math.fel.cvut.cz/en/people/heliskat/03Kohutka26en.html>

The final session was devoted to planning future cooperation. The local COST Action group agreed to prepare joint grant applications aimed at organizing innovative thematic meetings and workshops, potentially involving additional working groups and industry partners.

## Acknowledgement

The organizers gratefully acknowledge financial support from the COST Action CA24122, which made the organization of the STOCHASTIKA workshop possible and enabled international participation.

# STOCHASTIKA 2026 - program

## Sunday, February 8

16:00 – 24:00 *Registration*

18:30 – 20:00 *Dinner*

20:00 – 24:00 *Social evening*

## Monday, February 9

8:00 – 8:55 *Breakfast*

8:55 – 9:00 *Opening*

9:00 – 10:00 Morning session I (chairman: Zbyněk Pawlas):

9:00 – 9:30 Christian Pascal Hirsch: Functional central limit theorems for Laguerre tessellations

9:30 – 10:00 Martina Petráková: Point process convergence of large inradii of Poisson-Laguerre tessellation

10:00 – 10:30 *Coffee break*

10:30 – 11:30 Morning session II (chairman: Christian Pascal Hirsch):

10:30 – 11:00 Dominik Beck: Cluster expansion of dimer tilings

11:00 – 11:30 Zbyněk Pawlas: Statistical characteristics for orientations of symmetric objects

11:45 – 12:45 *Lunch*

13:00 – 16:00 *Discussion / work in groups / sports activities*

16:00 – 16:15 *Coffee break*

16:15 – 17:15 Afternoon session (chairman: Vesna Gotovac Đogaš):

16:15 – 16:45 Bogdan Radović: Dissimilarity assessment and classification of realisations of random sets

16:45 – 17:15 Jiří Dvořák: Bayesian inference for point processes and random sets: anisotropy, inhomogeneity and more

18:30 – 19:30 *Dinner*

19:30 – 24:00 *Social evening*

## Tuesday, February 10

8:00 – 9:00 *Breakfast*

9:15 – 10:15 Morning session I (chairman: Viktor Beneš):

9:15 – 9:45 Phillip Gräfensteiner: Structure-property relationships for nickel-rich cathodes of lithium-ion batteries, using resistor network simulations based on micro-CT image data

9:45 – 10:15 Léon F. Schröder: Machine-learning-based stereology methods for predicting 3D microstructures from 2D images

10:15 – 10:45 *Coffee break*

10:45 – 11:15 Morning session II (chairman: Léon F. Schröder):

11:15 – 11:45 Miroslav Šimlaštík: Modeling of boundary propagation in polycrystalline materials

11:45 – 12:45 *Lunch*

13:00 – 16:00 *Discussion / work in groups / sports activities*

16:00 – 16:15 *Coffee break*

16:15 – 17:15 Afternoon session (chairman: Phillip Gräfensteiner):

16:15 – 16:45 Julius Baumhake: Testing for isotropy of function-valued random fields

16:45 – 17:15 Vesna Gotovac Đogaš: Topological data analysis for random sets

18:30 – 19:30 *Dinner*

19:30 – 24:00 *Social evening*



## Wednesday, February 11

8:00 – 9:00 *Breakfast*

9:15 – 10:15 Morning session I (chairman: Petr Čoupek):

9:15 – 9:45 Bohdan Maslowski: On  $V$ -uniform ergodicity of stochastic infinite dimensional systems

9:45 – 10:15 Pavel Kříž: Hurst parameter estimation in discretely observed parabolic SPDEs

10:15 – 10:45 *Coffee break*

10:45 – 11:15 Morning session II (chairman: Pavel Kříž):

10:45 – 11:15 Volodymyr Sahan: Continuity of solutions to stochastic evolution equations driven by fractional processes in Banach spaces

11:45 – 12:45 *Lunch*

13:00 – 16:00 *Discussion / work in groups / sports activities*

16:00 – 16:15 *Coffee break*

16:15 – 17:15 Afternoon session (chairman: Bohdan Maslowski):

16:15 – 16:45 Filip Šťastný: Besov-Orlicz regularity of the Wiener rough path

16:45 – 17:15 Petr Čoupek: Differential equations driven by functions in exponential Besov–Orlicz spaces

18:30 – 19:30 *Dinner*

19:30 – 24:00 *Social evening*

## Thursday, February 12

8:00 – 9:00 *Breakfast*

9:00 – 10:00 Morning session I (chairman: Jiří Dvořák):

9:00 – 9:30 Martin Šmíd: Modelling market microstructure by point processes

9:30 – 10:00 Viktor Beneš: Development of stereology, with some applications to materials

10:00 – 10:30 *Coffee break*

10:30 – 11:30 Daniela Flimmel: Final COST discussion - future involvement



# STOCHASTIKA 2026

Kohútka

February 8-12, 2026

BOOK OF ABSTRACTS



RSJ

## List of affiliations of participants and coauthors of their contributions

- <sup>1</sup> Aarhus University, Department of Mathematics, Ny Munkegade 118, 8000 Aarhus C, Denmark
- <sup>2</sup> Charles University, Faculty of Mathematics and Physics, Department of Probability and Mathematical Statistics, Sokolovská 83, 186 75 Prague 8, Czech Republic
- <sup>3</sup> Czech Technical University in Prague, Faculty of Electrical Engineering, Department of Mathematics, Technická 2, 166 27 Prague 6, Czech Republic
- <sup>4</sup> Czech Academy of Sciences, Institute of Information Theory and Automation, Pod Vodárenskou věží 4, 182 08 Prague 8, Czech Republic
- <sup>5</sup> Graz University of Technology, Institute of Statistics, Kopernikusgasse 24/III, 8010 Graz, Austria
- <sup>6</sup> Ulm University, Institute of Stochastics, 89069 Ulm, Germany
- <sup>7</sup> University of Split, Faculty of Science, Department of Mathematics, Ruđera Boškovića 33, 21000 Split, Croatia
- <sup>8</sup> Institute for Applied Materials, Karlsruhe Institute of Technology, 76344 Eggenstein-Leopoldshafen, Germany
- <sup>9</sup> Helmholtz-Zentrum Berlin for Materials and Energy, Hahn-Meitner-Platz 1, 14109 Berlin, Germany
- <sup>10</sup> Customcells Itzehoe GmbH, Fraunhoferstraße 1d, 25524 Itzehoe, Germany
- <sup>11</sup> University of Hamburg, Department of Mathematics, Bundesstraße 55, 20146 Hamburg, Germany
- <sup>12</sup> University of Münster, Institute of Mathematical Stochastics, Orléans-Ring 10, 48149 Münster, Germany
- <sup>13</sup> Czech Academy of Sciences, Institute of Physics, Pod Vodárenskou věží 1, 182 08 Prague 8, Czech Republic
- <sup>14</sup> Hamburg University of Technology, Institute of Mathematics, Am Schwarzenberg-Campus 3, 21073 Hamburg, , Germany

# Testing for isotropy of function-valued random fields

Julius Baumhake<sup>5</sup>

baumhake@tugraz.at

Coauthors: Siegfried Hörmann<sup>5</sup>, Matthias Neumann<sup>5</sup>

## Abstract

We propose a new nonparametric approach for testing isotropy, i.e. invariance in distribution under rotations around the origin, of function-valued random fields. The key idea is to extract local, directional-dependent characteristics of the field and analyze their distributions with appropriate adjustments to account for spatial dependence. While function-valued random fields are well studied in spatial statistics, nonparametric methods for assessing their isotropy have not yet been established, and our framework is designed to fill this gap.

We outline how such a test can be used for applications in materials science. In particular, we use it to assess cylindrical isotropy of local volume fractions in paper-based materials which have been extracted from 3D image data.

**Acknowledgment:** This article is based upon work from COST Action mSPACE, CA24122, supported by COST (European Cooperation in Science and Technology).

# Cluster expansion of dimer tilings

Dominik Beck <sup>2</sup>

beckd@karlin.mff.cuni.cz

## Abstract

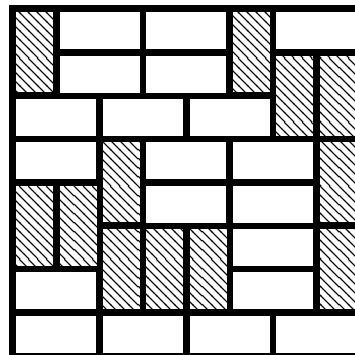
Many exact counting problems suffer the feared combinatorial explosion. As a toy model, consider a (non-overlapping) domino tiling of the standard  $8 \times 8$  chess board. One such tiling is shown below.

In total, there are  $Z_{8,8} = 12\,988\,816$  of all such tilings. For a general  $n \times n$  board, the total number  $Z_{n,n}$  of all tilings grows exponentially with the size of the board. More concretely, we have  $\ln Z_{n,n} \approx Cn^2$  with  $C \approx 0.29156$ . Hence, counting the exact number of tilings quickly becomes infeasible. However, by tying dimer tilings with pf-fafians, Kasteleyn [1] showed that  $C = G/\pi$ , where

$G = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)^2} \approx 0.9159655941$  is the *Catalan's constant*.

Unfortunately, Kasteleyn method is only applicable for dimers and for special lattices. An alternative and more general approach (although only numerical) is by generating the tiles randomly (allowing overlaps) and keeping track of their interactions. The resulting structure is amenable by means of the so called Cluster Expansion Technique [2].

In our talk, we introduce the technique and apply it on the problem of counting all domino tilings in  $n \times n$  boards, deducing the constant  $C$  numerically.



An  $8 \times 8$  domino tiling

## References

- [1] Kasteleyn P.W. (1961): *The statistics of dimers on a lattice: I. The number of dimer arrangements on a quadratic lattice*. *Physica* **27**(12), 1209–1225.
- [2] Kotecký R., Preiss D. (1986): *Cluster expansion for abstract polymer models*. *Communications in Mathematical Physics* **103**(3), 491–498. Springer

# Development of stereology, with some applications to materials

Viktor Beneš <sup>2</sup>

`viktor.benes@matfyz.cuni.cz`

## Abstract

This is a survey talk with several goals. We start with classical stereology of 3D particles observed in 2D sections by a prescribed sampling design. Theoretical solution was subsequently developed in two directions, first considering more complex shapes of particles and secondly involving multivariate characteristics such as size, shape and orientation. A recent trend is the extension of classical stereology to random tessellations. Solution of a stereological problem for the distribution of weights of Poisson-Laguerre tessellation leads again to Abel-type integral equation [1].

A new class of stereological problems, that arise in the investigation of polycrystalline materials, is that one with an additional information given by crystallographic orientations. While we observe a 2D tessellation in the section plane, an average orientation is fixed for entire 3D cells. A stochastic model of deformation twinning with lamellar defects was developed in [2]. Using the additional information it is possible to solve the stereological problem for the joint distribution of the habit plane normal and lamellae thickness.

**Acknowledgment:** The support from COST Action mSPACE, CA24122, is highly appreciated.

## References

- [1] van der Jagt T., Jongbloed G., and Vittorietti M. (2025): Nonparametric inference for Poisson-Laguerre tessellations. *Scandinavian Journal of Statistics* **52**(4), 1816–1851.
- [2] Kornijčuk O., Heller L., Pawlas Z., and Beneš V. (2025): Random marked nested tessellations applied to the modelling of deformation twinning in polycrystalline materials. *Preprint arXiv:2507.14405v1* [math-ph].

# Differential equations driven by functions in exponential Besov–Orlicz spaces

Petr Čoupek <sup>2</sup>

`coupek@karlin.mff.cuni.cz`

Coauthors: František Hendrych <sup>2</sup>, Jakub Slavík <sup>4</sup>

## Abstract

In the presentation, I will talk about regularity of solutions to SDEs with nonlinear multiplicative noise whose trajectories lie in exponential Besov–Orlicz spaces. Examples include the classical Wiener process, fractional Brownian motions, Rosenblatt or other higher-order Hermite processes. Instead of relying on probabilistic aspects of the driver, the path regularity of the noise is exploited and the equations are interpreted in the Young or Rough-path sense. Existence and uniqueness of the solution is proved by a fixed-point argument and it is shown that the regularity of the driver transfers to the regularity of the solution.

## References

- [1] Čoupek P., Hendrych F., Slavík J. (2026): Rough differential equations driven by Besov–Orlicz paths. *Potential Analysis* **64**, art.no. 3.
- [2] Čoupek P., Hendrych F., Slavík J. (2025): Young differential equations driven by Besov–Orlicz paths. *Discrete & Continuous Dynamical Systems—B* **30**(11), 4296–4311.

# Bayesian inference for point processes and random sets: anisotropy, inhomogeneity and more

Jiří Dvořák <sup>2</sup>

`dvorak@karlin.mff.cuni.cz`

## Abstract

Point processes can be used for modelling random occurrence of objects or events in a spatial or spatio-temporal domain. The natural application areas include ecology, materials science, epidemiology, and many others. Point processes also serve as building blocks for popular models of random sets, often used for modelling materials, forest populations, and more.

Some models of point processes and random sets are particularly suited for Bayesian analysis. The reason is that some unobserved information, which would greatly simplify the form of the likelihood, can be supplemented in the Bayesian MCMC approach. This applies e.g. to cluster point process models (where offspring points are clustered around unobserved parent points) or the Boolean models of random sets (where the union of particles is observed but not the individual particles or their centers).

In this talk, we discuss the benefits of the Bayesian approach in fitting of anisotropic cluster point processes, where inhomogeneity in the shape of the clusters and/or the orientation of the clusters can be considered. This allows much finer analysis compared to the classical methods. We also consider the case of the Boolean models, where again various types of inhomogeneity can be investigated easily in the Bayesian setting.

**Acknowledgment:** The support from COST Action mSPACE, CA24122, is highly appreciated.

# Topological data analysis for random sets

Vesna Gotovac Đogaš <sup>7</sup>

vgotovac@pmfst.hr

Coauthor: Marcela Mandarić <sup>7</sup>

## Abstract

This work paves the way for a methodology for detecting outliers and testing the goodness-of-fit of random sets using topological data analysis. Our approach is based on building a filtration using the sublevel sets of the signed distance function and analyzing various summary functions derived from the persistence diagrams of the resulting persistent homology. Outlier detection is performed using functional depth measures applied to these summary functions. To evaluate goodness-of-fit, we use global envelope tests with summary statistics serving as test statistics. The methodology is supported by a simulation study based on random set germ-grain models and is also applied to real-world data from histological images of mastopathic and breast cancer tissue.

**Acknowledgment:** The support from COST Action mSPACE, CA24122, is highly appreciated.

## References

- [1] Gotovac Đogaš V., Mandarić M. (2025): Topological data analysis for random sets and its application in detecting outliers and goodness of fit testing. *Stat Methods Appl* **34**, 561–605.

# Structure-property relationships for nickel-rich cathodes of lithium-ion batteries, using resistor network simulations based on micro-CT image data

Phillip Gräfensteiner <sup>6</sup>

`phillip.graefensteiner@uni-ulm.de`

Coauthors: Alexandra Pamperin <sup>8</sup>, Markus Osenberg <sup>9</sup>,  
Rasmus Himstedt <sup>10</sup>, Matthias Neumann <sup>5</sup>, Benedikt Prifling <sup>6</sup>,  
Ingo Manke <sup>9</sup>, Marc Kamlah <sup>8</sup>, Volker Schmidt <sup>6</sup>

## **Abstract**

Macroscopic effective properties of battery materials are predominantly influenced by the morphology of their microstructure. In order to bridge the gap between these different length-scales, a stochastic 3D microstructure model is combined with physical simulations on the electrode scale. More precisely, the stochastic model is used to generate virtual, but realistic microstructures of cathodes in lithium ion-batteries. The model is calibrated to tomographic image data and validated with respect to various geometric descriptors and effective transport properties. By varying the parameters of the model, a data base of artificial microstructures with varying densities and particle size distributions is created. Subsequently, the available data is used to investigate structure-property-relationships, which link geometric descriptors of the microstructure to effective properties of the material. In particular, resistor network modeling is used for computing the effective conductivity on the electrode scale, in which the microstructure is represented by a simplified graph structure. This graph structure, the so-called resistor network, is constructed based on virtual and experimental image data on the microscopic scale. Finally, the results are used to validate a previously established empirical formula that uses geometric descriptors of the microstructure to predict the macroscopic effective conductivity.

# Functional central limit theorems for Laguerre tessellations

Christian Pascal Hirsch <sup>1</sup>

hirsch@math.au.dk

Coauthors: Chinmoy Bhattacharjee <sup>11</sup>, Anna Gusakova <sup>12</sup>

## **Abstract**

We study functional central limit theorems for empirical estimators arising in Poisson–Laguerre tessellations. In particular, we consider estimators for the intensity and for a volume-weighted intensity of extreme points, viewed as stochastic processes indexed by time. For fixed time points, we derive quantitative multivariate normal approximation results in the Wasserstein distance and establish covariance asymptotics. Tightness is then shown, which allows us to deduce functional convergence in the Skorokhod topology to a centered Gaussian process. The results extend earlier univariate limit theorems and provide a functional framework for inference in Laguerre tessellations.

# Hurst parameter estimation in discretely observed parabolic SPDEs

Pavel Kríž<sup>2</sup>

`kriz@karlin.mff.cuni.cz`

## **Abstract**

In this talk, I present a method for estimating the Hurst (self-similarity) index of the driving noise in the stochastic heat equation will be presented. The core idea is to extend the widely-used quadratic variation approach, typically applied to scalar processes, to spatio-temporal data. To achieve this, temporal rescaling is replaced by a (parabolic) spatio-temporal rescaling, ensuring that the estimation procedure is consistent in both time (increasing temporal resolution) and space (increasing spatial resolution), while maintaining natural convergence rates. This spatio-temporal approach will be examined in the context of two common observation settings: spectral and local. The talk is based on the joint work with Gregor Pasemann (HU Berlin).

# On $V$ -uniform ergodicity of stochastic infinite dimensional systems

Bohdan Maslowski <sup>2</sup>

`maslow@karlin.mff.cuni.cz`

## **Abstract**

The aim of the talk is to recall some results on  $V$ -uniform and exponential uniform ergodicity for stochastic equations in infinite dimensions. The conditions are formulated in terms of transition probability functions of the induced Markov processes in a general form. The most important applications of the general result seem to be the stochastic reaction-diffusion equation, stochastic Burgers equation and stochastic 2D Navier-Stokes equation. The general assumptions are specified (and verified) in these cases.

# Statistical characteristics for orientations of symmetric objects

Zbyněk Pawlas <sup>2</sup>

pawlas@karlin.mff.cuni.cz

## **Abstract**

In this contribution, we present several statistical characteristics for random orientations of symmetric three-dimensional objects. Data of this type arise in various scientific fields, such as biomechanics, geophysics, crystallography, and materials science. We explain how object symmetries influence basic characteristics, with a particular focus on characteristics describing the mean orientation, variability, measures of centrality, and measures of dependence.

**Acknowledgment:** The support from COST Action mSPACE, CA24122, is highly appreciated.

# Point process convergence of large inradii of Poisson-Laguerre tessellation

Martina Petráková <sup>2</sup>

petrakova@karlin.mff.cuni.cz

Coauthor: Matthias Schulte <sup>14</sup>

## Abstract

The object of our research is the Poisson–Laguerre tessellation, i. e. a random Laguerre tessellation whose generator is a stationary Poisson marked point process  $\eta$ . In this contribution, we will consider a setting with uniformly bounded marks and a setting with heavy-tailed marks. We study the behaviour of the large inradii of the cells, where the inradius of a cell  $L((x, m), \eta)$  generated by the point  $(x, m)$  is defined as

$$r((x, m), \eta) := \begin{cases} \sup\{r \geq 0 : b(x, r) \subseteq L((x, m), \eta)\}, & x \in L((x, m), \eta), \\ 0, & x \notin L((x, m), \eta). \end{cases}$$

We discuss the point process convergence of large inradii and as a corollary, we get a convergence in distribution for the correctly rescaled maximal inradius.

**Acknowledgment:** This work was supported by the Charles University Grant Agency, project no. 70524.

# Dissimilarity assessment and classification of realisations of random sets

Bogdan Radović <sup>3</sup>

radovbog@fel.cvut.cz

Coauthors: Kateřina Helisová <sup>3</sup>, Jakub Staněk <sup>3</sup>, Vesna Gotovac Đogaš <sup>7</sup>

## Abstract

The first part of the talk concerns a statistical method for assessing dissimilarity of two random sets based on one realisation of each of them. The method focuses on shapes of the components of the random sets, namely on the curvature of their boundaries together with the ratios of their perimeters and areas. First, theoretical background is introduced. Then, the method is described, justified by a simulation study and applied to real data of two different types of tissue - mammary cancer and mastopathy.

The second part of the talk concerns methods for classification of realisations of random sets. The methods combine functional data analysis and spatial statistics procedure derived for random sets. The functional data obtained in the first part is used for nonparametric classification using both supervised and unsupervised approach based on k-nearest neighbours, k-medoids and agglomerative hierarchical clustering algorithms, respectively. The proposed methods are again justified through a simulation study and applied to the same medical data.

**Acknowledgment:** The support from COST Action mSPACE, CA24122, is highly appreciated.

## References

- [1] Gotovac Đogaš V., Helisová K., Radović B., Staněk J., Zikmundová M., and Brejchová K. (2021): Two-step method for assessing similarity of random sets. *Image Analysis and Stereology*, **40**, 127–140.
- [2] Radović B., Gotovac Đogaš V., and Helisová K. (2025): Classification of realisations of random sets. *arXiv preprint arXiv:2511.00937*

# Continuity of solutions to stochastic evolution equations driven by fractional processes in Banach spaces

Volodymyr Sahan <sup>2</sup>

volodymyr.sahan202@student.cuni.cz

## Abstract

A large class of partial differential equations with random input (e.g., stochastic heat conduction equations) can be understood as differential equations in an infinite-dimensional space [2]. If the equation is linear and the additive noise is fractional (its autocovariance function is identical to the autocovariance function of fractional Brownian motion), the solution to this equation is a stochastic convolution integral with values in a general, possibly non-UMD, Banach space (a generalization of the classical case of the Ornstein-Uhlenbeck process), and sufficient and necessary conditions for the existence and measurability of this solution can be found [1]. There is also a simple criterion for the continuity of the trajectories of this solution, which is based on the Kolmogorov-Cencov theorem and requires the analyticity of the relevant semigroup (i.e., it can be used for the heat equation, but not for the wave equation). In the talk, I will discuss this result and its possible extension to non-analytic semigroups via, e.g., the factorization technique

**Acknowledgment:** The support of the RSJ Foundation is gratefully acknowledged.

## References

- [1] Čoupek P., Maslowski B., Ondreját M. (2022): Stochastic integration with respect to fractional processes in Banach spaces. *Journal of Functional Analysis* **282**(8).
- [2] Da Prato G., Zabczyk J. (2014): *Stochastic Equations in Infinite Dimensions, 2nd ed.* Cambridge University Press, Cambridge.

# Machine-learning-based stereology methods for predicting 3D microstructures from 2D images

Léon F. Schröder <sup>6</sup>

`leon.schroeder@uni-ulm.de`

Coauthors: Lukas Fuchs <sup>6</sup>, Volker Schmidt<sup>6</sup>

## Abstract

The 3D microstructure of materials strongly influences their macroscopical properties, including mechanical and electrochemical performance. Thus, a deeper understanding of the 3D geometry of these materials is crucial to establish structure-property relationships. Direct 3D imaging techniques, such as 3D FIB-SEM tomography, are often impractical due to high costs and long acquisition times. In contrast, 2D images are comparatively accessible and cost-effective, but provide only little insight into the full 3D microstructure. This motivates the development of methods that infer 3D microstructural information from 2D image data alone. In this talk, we present several machine-learning-based methods for this purpose. Specifically, we introduce a stereological generative adversarial network-based model fitting approach to statistically reconstruct the inner grain architecture of NMC811 particles [1]. Furthermore, we propose convolutional neural network-based approaches for modeling 3D hetero-aggregates from 2D STEM images [2] and the 3D microstructure of the anodes of solid-oxide fuel cells from 2D SEM images [3]. These examples illustrate the potential of data-driven stereology to enable efficient 3D microstructure characterization and reconstruction from 2D imaging techniques.

## References

- [1] Fuchs L., Furat O., Finegan D.P., Allen J., Usseglio-Viretta F.L.E., Ozdogru B., Weddle P.J., Smith K., Schmidt V. (2025): Generating multi-scale Li-ion battery cathode particles with radial grain architectures using stereological generative adversarial networks. *Communications Materials* **6**(1), 4.

- [2] Fuchs L., Kirstein T., Mahr C., Furat O., Baric V., Rosenauer A., Mädler L., Schmidt V. (2024): Using convolutional neural networks for stereological characterization of 3D hetero-aggregates based on synthetic STEM data. *Machine Learning: Science and Technology* **5**(2), 025007
  
- [3] Schröder L., Weber S., Fuchs L., Schmidt V., Prifling B. (2025): Predicting the 3D microstructure of SOFC anodes from 2D SEM images using stochastic microstructure modeling and CNNs.  
*arXiv preprint arXiv:2510.20502*

# Modeling of boundary propagation in polycrystalline materials

Miroslav Šimlaščík <sup>2</sup>

`mirko.simlastik@gmail.com`

Coauthors: Lukáš Kadeřávek <sup>13</sup>, Viktor Beneš <sup>2</sup>

## Abstract

In NiTi-based shape memory polycrystalline alloys, reversible martensitic transformations occur through solid-state phase changes in the internal microstructure. These transformations are inherently localized and may occur on multiple scales, including mesoscopic and macroscopic levels. The localized transformation process nucleates and subsequently propagates through the alloy during phase change. The reversibility of the transformation - and therefore the propagation behavior - is limited by the strain compatibility and crystallographic constraints of the phase transformation, as well as other factors influenced by the crystallographic orientations of individual grains.

In this talk, we introduce a simple mathematical framework for the stochastic modeling of phase transformation propagation in polycrystalline materials. Firstly, we analyze this phenomenon using computer simulations. The resulting data enable a statistical evaluation and comparison of transformation propagation properties.

Secondly, we analyze experimental diffraction data of martensitic transformation in Nitinol during deformation. In the initial stage, activation occurs through the nucleation and propagation of martensitic bands in grains that are originally fully austenitic. In the subsequent stage, the growth of existing bands, the nucleation of new bands, their interaction, and propagation into neighboring grains take place. Basic statistical analyzes of these processes will be presented and discussed.

**Acknowledgment:** M. Šimlaščík would like to express his gratitude to the RSJ Foundation for their financial support.

# Modelling market microstructure by point processes

Martin Šmíd <sup>4</sup>

smid@utia.cas.cz

Coauthor: Aleš Antonín Kuběna <sup>4</sup>

## Abstract

We investigate price and volume dynamics in modern financial markets driven by the interplay of incoming buy and sell orders. Prices and traded volumes are modeled as nontrivial functions of order book queues, which are described by processes of discrete random measures.

For batch auctions, we derive semi-analytic expressions for the joint distribution of the clearing price and total traded volume, together with asymptotic results in relevant scaling regimes. For continuous double auctions, where the dynamics are more complex, we outline a novel general Markovian framework whose level of abstraction lies between transition kernels and generators. We also present preliminary results on conditional distributions of price and volume.

## References

- [1] Šmíd M. (2012): Probabilistic properties of the continuous double auction. *Kybernetika* **48**(1), 50–82.
- [2] Šmíd M. (2016): Estimation of zero-intelligence models by L1 data. *Quantitative Finance* **16**(9), 1423–1444.

# Besov-Orlicz regularity of the Wiener rough path

Filip Štastný <sup>2</sup>

filip.stastny946@student.cuni.cz

## Abstract

The purpose of the rough paths theory is to give meaning to differential equations of the form  $dY_t = f(Y_t) dX_t$ , where the integrator is not regular enough to understand this equation in the "classical" sense. In the theory, one defines an appropriate map  $\mathbb{X}$  that represents the postulated values of the iterated integral of increments of  $X$  against itself. If  $X$  and  $\mathbb{X}$  satisfy certain algebraic and regularity conditions, it is possible to formally define an integral against "rough path"  $\mathbf{X} = (X, \mathbb{X})$ .

In this talk, the Besov-Orlicz regularity will be considered and we will show that the canonical rough path constructed above the  $d$ -dimensional Wiener process is precisely of this regularity.

**Acknowledgment:** I would like to thank the RSJ Foundation for financial support.