Andreas Eberle

Academic career

1998	PhD, University of Bielefeld
1998 - 1999	Postdoc, Paul Sabatier University (Toulouse III), France
1999 - 2000	DFG research grant, University of California, San Diego, CA, USA
2000 - 2001	Teaching Assistant, University of Bielefeld
2001 - 2003	Lecturer, University of Oxford and Worcester College, UK
2009 - 2016	Head of Examination Board for Bachelor and Master Studies, Bonn
Since 2003	Professor (C3), University of Bonn

Invited Lectures

2000	Stochastic analysis and applications, Lisbon, Portugal
2002	Stochastic analysis, Beijing, China
2004	Stochastic partial differential equations and applications, Levico, Italy
2011	Filtering, MCMC, ABC, Lille, France
2016	Computational statistics and molecular simulation, Paris, France

Research Projects and Activities

Procope-Project: Quantitative convergence rates for diffusions by coupling methods

Research profile

My research is based on the combination of methods from probability theory and other branches of mathematics, including differential equations and functional analysis, numerical analysis, geometry, and mathematical physics. A current focus is on coupling methods for stochastic processes on continuous state spaces. Here, a common goal is to quantify stability properties and convergence to equilibrium, for example for stochastic differential equations, systems with mean-field interactions, processes with high and infinite dimensional state spaces, numerical approximations, and both Markov Chain Monte Carlo and sequential Monte Carlo methods. An important tool is an approach developed in recent years that is based on contraction properties for combinations of reflection couplings and other couplings in specifically adjusted Kantorovich distances. Both the underlying metric and the coupling are adapted carefully to the corresponding problem, thus providing quantitative non-asymptotic bounds that are often relatively precise. The approach has first been applied successfully to non-degenerate diffusion processes. More recently, it has been extended to mean-field systems and nonlinear equations with weak interactions, and variants have been applied to numerical approximations and a class of MCMC methods.

Markov Chain Monte Carlo methods are the source of a variety of non-trivial mathematical problems. One example of current interest is the observation that often non-reversible processes seem to approach equilibrium faster than the more standard reversible ones. The question how to implement non-reversible processes in MCMC in the most effective way is still widely open. This is complemented by a much more incomplete mathematical understanding of the long time behavior of non-reversible Markov processes compared to reversible ones. Coupling methods are not based on reversibility. Therefore, they might help to clarify these important questions. First steps in this direction are made in current work in progress which shows that a similar coupling approach as described above yields qualitatively new bounds for convergence to equilibrium of (kinetic) Langevin equations. A goal of my future research is to extend these results to related Monte Carlo methods, and also to other stochastic systems with degenerate noise. Another important question, arising for example in the study of sequential Monte Carlo

methods, is how to quantify the deviation of a mean-field approximation from a corresponding nonlinear SDE. Coupling methods might help to gain new insight. More generally, coupling approaches are natural for deriving long-time stable bounds for the difference between two different stochastic dynamics. First steps in this direction are done in current work in progress on sticky couplings.

Editorships

- Annals of Applied Probability (Associate Editor, 2014 - 2019)

Supervised theses

Master theses: 32, currently 8
Diplom theses: 30
PhD theses: 4

Selected PhD students

Nikolaus Schweizer (2012): “Non-asymptotic Error Bounds for Sequential MCMC Methods”, now Assistant Professor, Tilburg University, Netherlands
Daniel Gruhlke (2014): “Convergence of multilevel MCMC methods on path spaces”
Raphael Zimmer (2017): “Couplings and contractions with explicit rates for diffusions”
Mateusz Majka (2017): “Stability of stochastic differential equations with jumps by the coupling method”

Selected publications

[1] A. Guillin and R. Zimmer. Couplings and quantitative contraction rates for langevin dynamics. *Annals of Probability*, 47(4), 2019.
[2] A. Guillin and R. Zimmer. Quantitative harris type theorems for diffusions and mckean-vlasov processes. *Transactions AMS*, 371(10), 2019.
[3] R. Zimmer. Sticky couplings of multidimensional diffusions with different drifts. *Annales de l'Institut Henri Poincar'e - Probabilit'es et Statistiques*, 55(4), 2019.
[4] Andreas Eberle. Reflection couplings and contraction rates for diffusions. *Probab. Theory Related Fields*, 166(3-4):851–886, 2016.
[5] Andreas Eberle. Error bounds for metropolis-hastings algorithms applied to perturbations of gaussian measures in high dimensions. *Ann. Appl. Probab.*, 24(1):337–377, 2014.
[6] Andreas Eberle and Carlo Marinelli. Quantitative approximations of evolving probability measures and sequential markov chain monte carlo methods. *Probab. Theory Related Fields*, 155(3-4):665–701, 2013.
[7] Andreas Eberle. Local spectral gaps on loop spaces. *J. Math. Pures Appl. (9)*, 82(3):313–365, 2003.
[8] Andreas Eberle. Absence of spectral gaps on a class of loop spaces. *J. Math. Pures Appl. (9)*, 81(10):915–955, 2002.
[9] Andreas Eberle. *Uniqueness and non-uniqueness of semigroups generated by singular diffusion operators*, volume 1718 of *Lecture Notes in Mathematics*. Springer-Verlag, Berlin, 1999.