SpringerBriefs in Probability and Mathematical Statistics

Haesung Lee · Wilhelm Stannat · Gerald Trutnau



Analytic Theory of Itô-Stochastic Differential Equations with Nonsmooth Coefficients





SpringerBriefs in Probability and Mathematical Statistics

Editor-in-Chief

Gesine Reinert, University of Oxford, Oxford, UK

Series Editors

Nina Gantert, Technische Universität München, Munich, Germany Tailen Hsing, University of Michigan, Ann Arbor, MI, USA Richard Nickl, University of Cambridge, Cambridge, UK Sandrine Péché, Université Paris Diderot, Paris, France Yosef Rinott, Hebrew University of Jerusalem, Jerusalem, Israel Almut E.D. Veraart, Imperial College London, London, UK SpringerBriefs present concise summaries of cutting-edge research and practical applications across a wide spectrum of fields. Featuring compact volumes of 50 to 125 pages, the series covers a range of content from professional to academic. Briefs are characterized by fast, global electronic dissemination, standard publishing contracts, standardized manuscript preparation and formatting guidelines, and expedited production schedules.

Typical topics might include:

- A timely report of state-of-the art techniques
- A bridge between new research results, as published in journal articles, and a contextual literature review
- A snapshot of a hot or emerging topic
- Lecture of seminar notes making a specialist topic accessible for non-specialist readers
- SpringerBriefs in Probability and Mathematical Statistics showcase topics of current relevance in the field of probability and mathematical statistics

Manuscripts presenting new results in a classical field, new field, or an emerging topic, or bridges between new results and already published works, are encouraged. This series is intended for mathematicians and other scientists with interest in probability and mathematical statistics. All volumes published in this series undergo a thorough refereeing process.

The SBPMS series is published under the auspices of the Bernoulli Society for Mathematical Statistics and Probability.

All titles in this series are peer-reviewed to the usual standards of mathematics and its applications.

Analytic Theory of Itô-Stochastic Differential Equations with Non-smooth Coefficients



Haesung Lee
Department of Mathematics and Computer
Science
Korea Science Academy of KAIST
Busan, Korea (Republic of)

Gerald Trutnau
Department of Mathematical Sciences
and Research Institute of Mathematics
Seoul National University
Seoul, Korea (Republic of)

Wilhelm Stannat (5)
Institut für Mathematik
Technische Universität Berlin
Berlin, Germany

ISSN 2365-4333 ISSN 2365-4341 (electronic) SpringerBriefs in Probability and Mathematical Statistics ISBN 978-981-19-3830-6 ISBN 978-981-19-3831-3 (eBook) https://doi.org/10.1007/978-981-19-3831-3

© The Author(s), under exclusive license to Springer Nature Singapore Pte Ltd. 2022

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors, and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd. The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Acknowledgments

The research of Haesung Lee was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2020R1A6A3A01096151) and by the DFG through the IRTG 2235 "Searching for the regular in the irregular: Analysis of singular and random systems." The research of Wilhelm Stannat was partially supported by the DFG through the Research Unit FOR 2402 "Rough paths, stochastic partial differential equations and related topics." The research of Gerald Trutnau was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2017R1D1A1B03035632).

Contents

1	Intr	roduction			
	1.1	Methods and Results			
	1.2	Organization of the Book			
2	The	e Abstract Cauchy Problem in L ^r -Spaces with Weights			
	2.1	The Abstract Setting, Existence and Uniqueness			
		2.1.1 Framework and Basic Notations			
		2.1.2 Existence of Maximal Extensions on \mathbb{R}^d			
		2.1.3 Uniqueness of Maximal Extensions on \mathbb{R}^d			
	2.2				
		Invariant Measures			
		2.2.1 Class of Admissible Coefficients and the Main Theorem			
		2.2.2 Proofs			
		2.2.3 Discussion			
	2.3	Regular Solutions to the Abstract Cauchy Problem			
	2.4	Irreducibility of Solutions to the Abstract Cauchy Problem			
	2.5	Comments and References to Related Literature			
3	Stochastic Differential Equations				
	3.1	Existence			
		3.1.1 Regular Solutions to the Abstract Cauchy Problem			
		as Transition Functions			
		3.1.2 Construction of a Hunt Process			
		3.1.3 Krylov-type Estimate			
		3.1.4 Identification of the Stochastic Differential Equation			
	3.2	Global Properties			
		3.2.1 Non-explosion Results and Moment Inequalities			
		3.2.2 Transience and Recurrence			
		3.2.3 Long Time Behavior: Ergodicity, Existence			
		and Uniqueness of Invariant Measures,			
		Examples/Counterexamples			

viii Conter	nts
-------------	-----

	3.3	Uniqueness	103			
		3.3.1 Pathwise Uniqueness and Strong Solutions				
		3.3.2 Uniqueness in Law (Via L^1 -Uniqueness)	111			
	3.4	Comments and References to Related Literature	115			
4	Conclusion and Outlook.					
References						
In	Index					