The 9th Workshop on Markov Processes and Related Topics

July 6-10, 2013

Emeishan Grand Hotel

Emei Campus, Southwest Jiaotong University

Organizers: Mu-Fa Chen(BNU), Han Yang(SWJTU)

Sponsors: Key Laboratory of Mathematics and Complex Systems of Ministry of Education, Beijing Normal University; School of Mathematics, Southwest Jiaotong University

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Website: http://math.bnu.edu.cn/probab/Workshop2013

	July 6	**July 7**	**July 9**	**July 10**
Chairman	**Feng-Yu Wang**	**Yimin Xiao**	**Renming Song**	**Shui Feng**
08:30-09:00	**8:20**开幕式及照相	Zhen-Qing Chen	Dayue Chen	Huaizhong Zhao
09:00-09:30	Yuh-Jia Lee	Xiaowen Zhou	Fubao Xi	Xian-Yuan Wu
09:30-10:00	Jie Xiong	Jian Wamg	Yong Liu	Wei Liu
10:00-10:30	Tea break			
10:30-11:00	Xia Chen	Shui Feng	Yaozhong Hu	Shunlong Luo
11:00-11:30	Jinghai Shao	Lianwen Zhao	Hua-Ming Wang	Hui He
Chairman	**Zhao Dong**	**Dayue Chen**	**Tzuu-Shuh Chiang**	**Mu-Fa Chen**
14:30-15:00	Yun-Shyong Chow	Tusheng Zhang	Xianping Guo	Renming Song
15:00-15:30	Yimin Xiao	Xicheng Zhang	Junping Li	Zhao Dong
15:30-16:00	Yuanyuan Liu	Xiangdong Li	Dejun Luo	Tea break
16:00-16:30	Tea break			Jiang-Lun Wu
16:30-17:00	Tzuu-Shuh Chiang	Yanxia Ren	Chenggui Yuan	Zhi-Ming Ma
17:00-17:30	Bo Wu	Jieming Wang	Xiaoming Fan	

July 6

Chairman: Feng-Yu Wang

08:20-09:00 Welcome talk and take pictures

09:00-09:30 Yuh-Jia Lee (University of Kaohsiung)

The Heisenberg inequality on abstract Wiener spaces

09:30-10:00 Jie Xiong (University of Macau and University of Tennessee)

Some nonlinear SPDEs from measures valued processes

10:00-10:30 Tea break

10:30-11:00 Xia Chen (University of Tennessee)

The limit law of the iterated logarithm

11:00-11:30 Jinghai Shao (Beijing Normal University)

Strong ergodicity of the regime-switching diffusion processes

Chairman: Zhao Dong

14:30-15:00 Yun-Shyong Chow (Institute of Mathematics, Academia Sinica)

Some results on evolutionary 2 x *2 asymmetric games*

15:00-15:30 Yimin Xiao (Michigan State University)

Brownian motion and thermal capacity

15:30-16:00 Yuanyuan Liu (Central South University)

The deviation matrix, Poisson's equation, and quasi-birth-death processes

16:00-16:30 Tea break

16:30-17:00 Tzuu-Shuh Chiang (Institute of Mathematics, Academia Sinica)

Asymptotic normality of occupation time of singularly perturbed diffusion processes

17:00-17:30 Bo Wu (Fudan University)

Some problems on Riemannian path and loop spaces

July 7

Chairman: Yimin Xiao

08:30-09:00 Zhen-Qing Chen (University of Washington)

An interacting diffusion model and its hydrodynamic limit

09:00-09:30 Xiaowen Zhou (Concordia University)

Support properties of Λ-Fleming-Viot processes with Brownian spatial motion

09:30-10:00 Jian Wang (Fujian Normal University)

Weighted Poincaré inequalities for nonlocal Dirichlet forms

10:00-10:30 Tea break

10:30-11:00 Shui Feng (McMaster University)

Derrida's random energy model and large deviations

11:00-11:30 Lianwen Zhao (Southwest Jiaotong University)

The central limit theorems for Markov processes

Chairman: Dayue Chen

14:30-15:00 Tusheng Zhang (University of Manchester and University of Science and Technology of China)

Strong approximations of reflected SDEs in a multidimensional general domain

15:00-15:30 Xicheng Zhang (Wuhan University)

Heat kernels and analyticity of non-symmetric Lévy diffusion semigroups

15:30-16:00 Xiangdong Li (Chinese Academy of Sciences)

Optimal transport, Fokker-Planck diffusion and Perelman's Ricci flow

16:00-16:30 Tea break

16:30-17:00 Yanxia Ren (Peking University)

The backbone decomposition for spatially dependent supercritical superprocesses

17:00-17:30 Jieming Wang (Beijing Institute of Technology)

Laplacian perturbed by non-local operators

July 9

Chairman: Renming Song

08:30-09:00 Dayue Chen (Peking University)

The motion of a tagged particle in the simple exclusion process

09:00-09:30 Fubao Xi (Beijing Institute of Technology)

Stability and instability for switching jump-diffusion processes

09:30-10:00 Yong Liu (Peking University)

On time regularity of Ornstein-Uhlenbeck equation driven by Lévy noise in Hilbert spaces

10:00-10:30 Tea break

10:30-11:00 Yaozhong Hu (University of Kansas)

A multiparameter Garsia-Rodemich-Rumsey inequality and some applications

11:00-11:30 Hua-Ming Wang (Anhui Normal University)

On total progeny of multitype Galton-Watson process and the first passage time of random walk on lattice

Chairman: Tzuu-Shuh Chiang

14:30-15:00 Xianping Guo (Sun Yat-Sen University)

Minimizing risk probability in semi-Markov decision processes

15:00-15:30 Junping Li (Central South University)

n-Type Markov branching processes with immigration

15:30-16:00 Dejun Luo (Chinese Academy of Sciences)

The fundamental gap conjecture: a probabilistic approach via the coupling by reflection

16:00-16:30 Tea break

16:30-17:00 Chenggui Yuan (Swansea University)

Exponential mixing for retarded stochastic differential equations

17:00-17:30 Xiaoming Fan (Southwest Jiaotong University)

Estimates of the blowup time for a stochastic semilinear wave equation with white noise

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July 10

Chairman: Shui Feng

08:30-09:00 Huaizhong Zhao (Loughborough University)

BDSDEs with polynomial coefficients

09:00-09:30 Xian-Yuan Wu (Capital Normal University)

Small world principle of the real-world networks

09:30-10:00 Wei Liu (Jiangsu Normal University)

Well-posedness and long time asymptotics of SPDE with locally monotone coefficients

10:00-10:30 Tea break

10:30-11:00 Shunlong Luo (Chinese Academy of Sciences)

Quantum non-Markovianity

11:00-11:30 Hui He (Beijing Normal University)

Pruning of CRT-sub-trees

Chairman: Mu-Fa Chen

14:30-15:00 Renming Song (University of Illinois)

Dirichlet heat kernel estimates for rotationally symmetric Lévy processes

15:00-15:30 Zhao Dong (Chinese Academy of Sciences)

Malliavin matrix of degenerate PDE and gradient estimates

15:30-16:00 Tea break

16:00-16:30 Jiang-Lun Wu (Swansea University)

Maximum principles for parabolic Waldenfels operators

16:30-17:00 Zhi-Ming Ma (Chinese Academy of Sciences)

q-Processes in modeling coalescent with recombination

The Motion of a Tagged Particle in The Simple Exclusion Process

Dayue CHEN *Peking University, PRC*, E-mail: dayue@math.pku.edu.cn
Peng Chen *Peking University, PRC*

Abstract: The simple exclusion process is an interacting particle system. There is no birth or death of particles. Each particle perform an independent random walk. The walk is suspended when a particle jumps to the site of another particle. Therefore a tagged particle behaviors very much like a random walk with a fixed rate of slow down. In this talk we shall review some limit theorems of a tagged particle in the simple exclusion and report our progress in this direction.

The Limit Law of The Iterated Logarithm

Xia CHEN *University of Tennessee, USA*, E-mail: xchen@math.utk.edu

KEY WORDS: The limit law of the iterated logarithm, Brownian motion, Ornstein-Uhlenbeck process.

MATHEMATICAL SUBJECT CLASSIFICATION: 60F15, 60G10, 60G15, 60G50.

Abstract: For the partial sum $\{S_n\}$ of an i.i.d. sequence with zero mean and unit variance, it is pointed out that

$$\lim_{n\to\infty} (2\log\log n)^{-1/2} \max_{1\le k\le n} \frac{S_k}{\sqrt{k}} = 1 \quad a.s.$$

References

[1] Chen, X. The limit law of the iterated logarithm. *J. Theor. Probab.*, **to appear**.

An Interacting Diffusion Model and Its Hydrodynamic Limit

Zhen-Qing CHEN *University of Washington, USA*, E-mail: zqchenuw.edu

Abstract: We introduce and study an interacting stochastic system of reflected diffusions in two adjacent bounded domains with annihilation occurring near the interface (the common part of the boundaries of two domains) to model transportation of positive and negative charges in solar cells. The new feature is the interaction of two classes of diffusions near the interface. We show that as the number of initial charges tend to infinity, the empirical process of the interacting diffusions converges to a measure-valued process whose density function is deterministic and satisfies a system of coupled parabolic differential equations with non-linear boundary condition at the interface of the media. Propagation of chaos will also be discussed. Based on joint work with Louis Fan.

Asymptotic Normality of Occupation Time of Singularly Perturbed Diffusion Processes

Wei-Da Chen *Institute of Mathematics, Academia Sinica, Taipei, Taiwan*
Tzuu-Shuh CHIANG *Institute of Mathematics, Academia Sinica, Taipei, Taiwan*,
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KEY WORDS: Central Limit Theorem, Singularly Perturbed Diffusions.

MATHEMATICAL SUBJECT CLASSIFICATION: Primary 60J60; Secondary 60F05,35C20.

Abstract: Let X_t^ϵ to台be a diffusion process on the unit circle S^1 with generator $L^\epsilon = 1/\epsilon \cdot L_1 + L_2$ where $L_i(t,x) = b_i(t,x)\partial x + 1/2 \cdot a_i(t,x)\partial xx$ are two diffusion generators for $i = 1, 2$. Here, $b_i(t,x)$ and $a_i(t,x)\,(> 0)$ are taken to be smooth functions on S^1. Given a bounded measurable function $f(x)$ on S^1, an unscaled function of the occupation time of X_t^ϵ is defined as

$$Z^\epsilon(t,f) = \int_0^t (f(X^\epsilon(s)) - \int_0^1 f(y)p(s,y)dy)ds.$$

where for each $t, p(t,y)$ is the quasi-stationary distribution of $L_1(t,y)$. In this paper, we shall first show that the law of large numbers of $Z^\epsilon(t,f)$ holds, i.e., $\lim_{\epsilon\to 0} Z^\epsilon(t,f) = 0$ in L^2 and hence in probability. Let $n^\epsilon(t,f) = 1/\sqrt{\epsilon} \cdot Z^\epsilon(t,f)$. The second result is to show that $n^\epsilon(\cdot,f)$ converges to a Gaussian process $n(\cdot,f)$ as $\epsilon \to 0$ and we will explicitly compute the covariance function of $n(\cdot,f)$.

Some Results on Evolutionary 2 x 2 Asymmetric Games

Yunshyong CHOW *Institute of Mathematics, Academia Sinica, Taipei, Taiwan*
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KEY WORDS: Nash equlibrium, Battle of Sex game, evolutionary games, local interaction, mutation

MATHEMATICAL SUBJECT CLASSIFICATION: 91A22; 60J20

Abstract: A typical 2 x 2 asymmetric game model is the Battle Of Sex game. There exist 3 Nash equilibria. Two are unlikely as players are not allowed to communicate with each other. The third one is a mixed strategy. Under which, the expectation payoff of each player is very low. That seems unreasonable. In the evolutionary game setup, we consider 2n players sitting around a circle with nearest neighborhood interaction. The long run equilibrium can be explicitly obtained and then the expectation payoff of each player can be computed, which largely improved the previous payoff.

References

[1] H.C. Chen & Y. Chow (2009). Evolutionary prisoner's dilemma games with one-dimensional local interaction and imitation, *Adv. Applied Probab.*, **41**, 154-176.

[2] J. Hofbauer & K. Sigmund (1998). Evolutionary Games and Replicator Dynamics, *Cambridge University Press.*

[3] J.H. Wang (1988). The Theory of Games, *Tsinghua University Press.*

Malliavin Matrix of Degenerate PDE and Gradient Estimates

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Xu Hui Peng *Academy of Mathematics and Systems Science, Chinese Academy of Sciences*

KEY WORDS: Degenerate stochastic differential equation,Gradient estimate,Strong Feller

MATHEMATICAL SUBJECT CLASSIFICATION: 60H10, 60H07

Abstract: In this talk, we present the bounded of the inverse for Malliavin Matrix of Degenerate PDE under a new condition, which is equivalent to the Hoermander condition as the coefficients are smooth. Also, the gradient estimatats for the semigroup is given.

References

[1] Shigekawa, I & (2004),Stochastic Analysis *Translations of Mathematical Monographs*.

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Estimates of The Blowup Time for a Stochastic Semilinear Wave Equation with White Noise

Xiaoming FAN *Southwest Jiaotong University, China*, E-mail: fanxm@aliyun.com

Abstract: By using prior time estimates, this paper obtains several blowup events and upper bounds of the blowup time in the events for a stochastic semilinear wave equation with white noise.

Derrida's Random Energy Model and Large Deviations

Shui FENG *McMaster University, Canada*, E-mail: shuifeng@mcmaster.ca

Abstract: Derrida's random energy model (REM) is a simple model for mean field spin glasses. It is approximated by a Poisson-Dirichlet distribution when the system becomes large. In this talk, we will explore this connection and provide a new explanation to some large deviation results.

Minimizing Risk Probability in Semi-Markov Decision Processes

Xianping GUO *Sun Yat-Sen University, China*; E-mail: mcsgxp@mail.sysu.edu.cn
Yonghui Huang *Sun Yat-Sen University, China*

KEY WORDS: Semi-Markov decision process, risk probability, target set, optimal policy, iteration algorithm.

MATHEMATICAL SUBJECT CLASSIFICATION: 90C40, 93E20

Abstract: This talk concerns with the risk probability criterion for semi-Markov decision processes. The goal of the optimization is to minimize the risk probability that a system reaches a prescribed reward level during a first passage time to a given target set. Besides the motivation of the work in this talk, we will show the main results, which include the establishment of the optimality equation, the existence of an optimal policy, a value iteration algorithm for computing the optimal value, and a numerable example.

References

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[2] Y.H. Huang, and X.P. Guo (2009). Optimal risk probability for first passage models in semi-Markov decision processes. *J. Math. Anal. Appl.*, **359**: 404-420

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Pruning of CRT-Sub-Trees

R. Abraham *Université de Orléans, France*
J.-F. Delmas *Université Paris-Est, France*
Hui HE *Beijing Normal University, Beijing*, E-mail: hehui@bnu.edu.cn

KEY WORDS: Pruning, branching process, Galton-Watson process, random tree, CRT, tree-valued process, Girsanov transformation

MATHEMATICAL SUBJECT CLASSIFICATION: 05C05, 60J80, 60J27

Abstract: We study the pruning process developed by Abraham and Delmas (2012) on the discrete Galton-Watson sub-trees of the Lévy tree which are obtained by considering the minimal sub-tree connecting the root and leaves chosen uniformly at rate λ, see Duquesne and Le Gall (2002). The tree-valued process, as λ increases, has been studied by Duquesne and Winkel (2007). Notice that we have a tree-valued process indexed by two parameters the pruning parameter θ and the intensity λ. Our main results are: construction and marginals of the pruning process, representation of the pruning process (forward in time that is as θ increases) and description of the growing process (backward in time that is as θ decreases) and distribution of the ascension time (or explosion time of the backward process) as well as the tree at the ascension time. A by-product of our result is that the super-critical Lévy trees independently introduced by Abraham and Delmas (2012) and Duquesne and Winkel (2007) coincide. This work is also related to the pruning of discrete Galton-Watson trees studied by Abraham, Delmas and He (2012).

References

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[2] R. ABRAHAM, J. DELMAS, and H. HE (2012): Pruning Galton-Watson trees and tree-valued Markov processes. *Ann. Inst. H. Poincaré*, **48**, 688-705.

[3] T. DUQUESNE and J. Le GALL (2002): *Random trees, Lévy processes and spatial branching processes*, **281**, Astérisque.

[4] T. DUQUESNE and M. WINKEL (2007): Growth of Lévy trees. *Probab. Th. and rel. Fields*, **139**, 313–371.

A Multiparameter Garsia-Rodemich-Rumsey Inequality and Some Applications

Yaozhong HU *University of Kansas, USA*, E-mail: hu@math.ku.edu
Khoa LE *University of Kansas, USA*

KEY WORDS: Joint Hölder continuity; Garsia-Rodemich-Rumsey inequality; sample path property; Gaussian processes, fractional Brownian fields; stochastic heat equations with additive noises.

MATHEMATICAL SUBJECT CLASSIFICATION: 60G17, 26A16, 60G60, 60G15, 60H15.

Abstract: We extend the classical Garsia-Rodemich-Rumsey inequality to the multiparameter situation. The new inequality is applied to obtain some joint Hölder continuity along the rectangles for fractional Brownian fields $W(t,x)$ and for the solution $u(t,y)$ of stochastic heat equation with additive white noise.

References

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The Heisenberg Inequality on Abstract Wiener Spaces

Yuh-Jia LEE *University of Kaohsiung, Taiwan*, E-mail: yjlee@nuk.edu.tw

KEY WORDS: Heisenberg Uncertainty Principle, Abstract Wiener spaces, Gaussian Measure

MATHEMATICAL SUBJECT CLASSIFICATION: Primary 60H40;Secondary 60H05, 60H07, 60J75

Abstract: The Heisenberg inequality associated with the uncertainty principle is extended to an infinite dimensional abstract Wiener space (H, B) with an abstract Wiener measure p_1. For $\varphi \in L^2(p_1)$ and $T \in L(B, H)$, it is shown that

$$\Big[\int_B |Tx|_H^2 \, |\varphi(x)|^2 \, p_1(dx)\Big] \Big[\int_B |Tx|_H^2 \, |\mathcal{F}\varphi(x)|^2 \, p_1(dx)\Big] \geq ||T|_H||_{HS}^4 \, ||\varphi||_2^4,$$

where $\mathcal{F}\varphi$ is the Fourier-Wiener transform of φ. The conditions when the equality holds also discussed.

References

[1] Gross, L. (1965). Abstract Wiener spaces, *Proc. 5th Berkeley Symp. Math. Stat. Prob.*, **2**, 31-42.

[2] Gross, L. (1967). Potential theory on Hilbert spaces, *J. Funct. Anal.*, **1**, 123-181.

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n-Type Markov Branching Processes with Immigration

Junping LI *Central South University, China*, E-mail: jpli@csu.edu.cn

Abstract: In this paper, we consider n-type Markov branching processes with immigration and resurrection. The uniqueness criteria are first established. Then, a new method is found and the explicit expression of extinction probability is successfully obtained in the absorption case, the mean extinction time is also given. The recurrence and ergodicity criteria are given if the state **0** is not absorptive. Finally, if the resurrection rates are same as the immigration rates, the branching property and decay property are discussed in detail, it is shown that the process is a superimposition of a n-type branching process and an immigration. The exact value of the decay parameter λ_Z is given for the irreducible class $\mathbf{Z}_+^n$. Moreover, the corresponding λ_Z-invariant measures/vectors and quasi-distributions are presented.

Optimal Transport, Fokker-Planck Diffusion and Perelman'S Ricci Flow

Xiangdong LI *Chinese Academy of Sciences, PRC,* E-mail: lxdli@amt.ac.cn

Abstract: We study the optimal transport problem between the Fokker-Planck diffusions on compact Riemannian manifolds equipped with Perelman's Ricci flow and conjugate heat equation. We prove that, whenever the Riemannian metric evolves along the Perelman's Ricci flow and the potential function evolves along the conjugate heat equation, the Wasserstein distance between two backward Fokker-Planck diffusions is non-decreasing In time. Moreover, we prove the displacement convexity of certain Bolztmann type entropy functionals on the Wasserstein space over compact manifolds equipped with Perelman's Ricci flow. Our work extends some previous results due to Otto, Villani, Sturm, von Rennese, McCann, Topping and Lott. This is a joint work with Songzi Li (Fudan University).

Well-Posedness and Long Time Asymptotics of SPDE with Locally Monotone Coefficients

Wei LIU *Jiangsu Normal University, China*, E-mail: weiliu@math.uni-bielefeld.de

Key words: SPDE; well-posedness; long time asymptotics; random attractor; Navier-Stokes equation.

Mathematical Subject Classification: 60H15, 37L30, 37L55, 34D45

Abstract: In this talk we will first present some recent results [1,2,3] on the well-posedness of SPDE with locally monotone coefficients, which substantially generalize the classical results by Pardoux [4], Krylov and Rozovskii [5] and also some recent works. This extension provides a unified framework to analyze a large class of SPDEs such as stochastic reaction-diffusion equations, stochastic Burgers type equations, stochastic 2D hydrodynamical systems, stochastic tamed 3D Navier-Stokes equations and stochastic equations of non-Newtonian fluids, which can not be included in the classical variational framework in [4,5,6].

The second part of this talk is to show the long time asymptotics of SPDE with locally monotone coefficients by proving the existence of random attractors [7]. The approach is based on a construction of strictly stationary nonlinear Ornstein-Uhlenbeck processes, which also allows spatially much rougher noise than in existing works. The main result is applicable to various types of SPDE, which improves many known results in the literature including recent works [8,9,10] on quasilinear SPDEs .

This talk is mainly based on some joint works with Michael Röckner (Universität Bielefeld) and Benjamin Gess (Technische Universität Berlin).

References

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On Time Regularity of Ornstein-Uhlenbeck Equation Driven by Lévy Noise in Hilbert Spaces

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KEY WORDS: càdlàg modification; Ornstein-Uhlenbeck equation, Lévy noise, α-stable process

MATHEMATICAL SUBJECT CLASSIFICATION: 60H15, 60G52

Abstract: In this talk, we will present some new progresses on the time regularity of generalized Ornstein-Uhlenbeck processes driven by Levy processes in Hilbert spaces. This talk is based on the following articles:

References

[1] Brzezniak, Z., Goldys, B., Imkeller, P., Peszat, S., Priola, E., Zabczyk, J. *Time irregularity of generalized Ornstein-Uhlenbeck processes*, C. R. Acad. Sci. Paris, Ser. I 348(2010),

[2] Liu, Y., Zhai, J.L. *A note on time regularity of generalized Ornstein-Uhlenbeck processes with cylindrical stable noise*, C. R. Acad. Sci. Paris, Ser. I 350(2012),

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[4] Liu, Y., Zhai, J.L. *On time regularity of SPDE in Hilbert spaces*, 2013. Preprint

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The Deviation Matrix, Poisson'S Equation, and Quasi-Birth-Death Processes

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Guy Latouche *Département dÍnformatique, Université Libre de Bruxelles, Belgium*,
Yuanyuan LIU *School of Mathematics, Central South University, China*,
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Abstract: We consider Poisson's equation for quasi-birth-and-death processes (QBDs) and we exploit the special transition structure of QBDs to obtain its solutions in two different forms. One is based on a decomposition through first passage times to lower levels, the other is based on a recursive expression for the deviation matrix.

It is interesting to note that a solution of Poisson's equation is closely linked with the central limit theorem and perturbation analysis. We conclude with the PH/M/1 queue as an illustrative example, and we measure the sensitivity of the expected queue size to the initial value.

The Fundamental Gap Conjecture: a Probabilistic Approach via The Coupling by Reflection

Fuzhou Gong *Institute of Applied Mathematics, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China*
Huaiqian Li *Institute of Applied Mathematics, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China*
Dejun LUO *Institute of Applied Mathematics, Academy of Mathematics and Systems Science, Chinese Academy of Sciences, China*, E-mail: luodj@amss.ac.cn

Key words: Schrödinger operator, spectral gap, ground state, coupling by reflection

Mathematical Subject Classification: 35P15, 60H10

Abstract: The fundamental gap conjecture asserts that the spectral gap of the Schrödinger operator $-\Delta + V$ with Dirichlet boundary condition on the bounded convex domain $\Omega \subset \mathbb{R}^n$ is greater than $\frac{3\pi^2}{D^2}$, provided that the potential $V : \bar{\Omega} \to \mathbb{R}$ is convex. Here $D > 0$ is the diameter of Ω. Using analytic methods, Andrews and Clutterbuck proved recently a more general spectral gap comparison result which implies the conjecture. In this work we shall give a probabilistic proof via the coupling by reflection of the diffusion processes.

References

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Quantum Non-Markovianity

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Abstract: In the study of open quantum systems, memory effects are usually ignored, and this leads to dynamical semi-groups and Markovian dynamics. However, in practice, non-Markovian dynamics is the rule rather than exception. With the recent emergence of quantum information theory, there is a flurry of investigations of non-Markovian dynamics. In this talk, we first review several significant measures for non-Markovianity, such as deviation from divisibility, information

exchange between a system and its environment, or entanglement with the environment. Then by exploiting the correlations flow between a system and an arbitrary ancillary, we study a considerably intuitive measure for non-Markovianity by use of correlations as quantified by the quantum mutual information rather than entanglement. The measure captures quite directly and deeply the characteristics of non-Markovianity from the perspective of information. A simplified version based on Jamiolkowski-Choi isomorphism which encodes operations via bipartite states and does not involve any optimization is also proposed.

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q-Processes in Modeling Coalescent with Recombination

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Abstract: The stochastic evolution of a DNA segment that experiences recombination is a complex process, there have been some analyses based on simulations or using heuristic methods. In collaboration with the CAS-MPG Partner Institute for Computational Biology and Beijing Jiaotong University, recently we have developed a rigorous mathematical model along with a new algorithm. We believe that our new model will advance the study of recombination. Our model relies heavily on the theory of q-processes. In this talk we shall describe in detail the q-process arising from our model and report the methods and techniques of q-processes which we have employed in the study of coalescent with recombination.

The Backbone Decomposition for Spatially Dependent Supercritical Superprocesses

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Key words: Superprocesses, $\mathbb{N}$-measure, backbone decomposition.

Mathematical Subject Classification: 60J80, 60E10.

Abstract: Consider any supercritical Galton-Watson process which may become extinct with positive probability. It is a well-understood and intuitively obvious phenomenon that, on the survival set, the process may be pathwise decomposed into a stochastically 'thinner' Galton-Watson process, which almost surely survives and which is decorated with immigrants, at every time step, initiating independent copies of the original Galton-Watson process conditioned to become extinct. The thinner process is known as the *backbone* and characterizes the genealogical lines of descent of prolific individuals in the original process. Here, prolific means individuals who have at least one descendant in every subsequent generation to their own.

Starting with Evans and O'Connell [5], there exists a cluster of literature, [4, 7, 3, 1, 6], describing the analogue of this decomposition (the so-called *backbone decomposition*) for a variety of different classes of superprocesses and continuous-state branching processes. Note that the latter family of stochastic processes may be seen as the total mass process of superprocesses with non-spatially dependent branching mechanism.

In this article we consolidate the aforementioned collection of results concerning backbone decompositions and describe a result for a general class of supercritical superprocesses with spa-

tially dependent branching mechanisms. Our approach exposes the commonality and robustness of many of the existing arguments in the literature. ...

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Strong Ergodicity of The Regime-Switching Diffusion Processes

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Abstract: In this talk, we provide criteria for the strong ergodicity of regime-switching diffusion processes. Our conditions are imposed on the coefficients of the processes. Particularly, we show that for regime-switching diffusions on the half line, if the corresponding diffusion on each fixed environment is strongly ergodic, then the regime-switching diffusion is strongly ergodic as well, which does not depend on the changing rate of the environment. Moreover, the converse is not always true, which is shown by an example. For transience, recurrence and positive recurrence, there is no such good consistency (R. Pinsky and M. Scheutzow, Ann. Inst. Henri. Poincaré, 1992).

Dirichlet Heat Kernel Estimates for Rotationally Symmetric Lévy Processes

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KEY WORDS: Lévy process, subordinate Brownian motion, heat kernel, Dirichlet heat kernel, transition density, Dirichlet transition density

MATHEMATICAL SUBJECT CLASSIFICATION: 60J35, 47G20, 60J75, 47D07

Abstract: In this talk I will present some recent results on sharp two-sided estimates for the transition densities of a large class of rotationally symmetric Lévy process killed upon exiting an open set D. When D is a κ-fat open set, the sharp two-sided estimates are given in terms of surviving probabilities and the global transition density of the Lévy process. When D is a $C^{1,1}$ open set and the Lévy exponent of the process is given by $\Psi(\xi) = \phi(|\xi|^2)$ with ϕ being a complete Bernstein function satisfying a mild growth condition at infinity, our two-sided estimates are explicit in terms of Ψ, the distance function to the boundary of D and the jumping kernel of X. The results are the first sharp two-sided Dirichlet heat kernel estimates for a large class of symmetric Lévy processes with general Lévy exponents.

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On Total Progeny of Multitype Galton-Watson Process and The First Passage Time of Random Walk on Lattice

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Key words: Multitype branching process, total progeny, random walk.

Mathematical Subject Classification: Primary 60J80; secondary 60G50.

Abstract: In this paper, we form a method to calculate the probability generating function of the total progeny of multitype branching process. As examples, we calculate probability generating function of the total progeny of the multitype branching processes within random walk which could stay at its position and (2-1) random walk. Consequently, we could give the probability generating functions and the distributions of the first passage time of corresponding random walks. Especially, for recurrent random walk which could stay at its position with probability $0 < r < 1$, we show that the tail probability of the first passage time decays as $\frac{2}{\sqrt{\pi(1-r)}}\frac{1}{\sqrt{n}}$ when $n \to \infty$.

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Weighted Poincaré Inequalities for Nonlocal Dirichlet Forms

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KEY WORDS: Non-local Dirichlet form; weighted Poincaré inequality

MATHEMATICAL SUBJECT CLASSIFICATION: 60G51; 60G52; 60J25; 60J75

Abstract: Let V be a locally bounded measurable function on R^d such that $\mu_V(dx) = C_V e^{-V(x)}\,dx$ is a probability measure. Explicit criterion are presented for weighted Poincaré inequalities of the following non-local Dirichlet form

$$D_{\rho,V}(f,f) = \iint_{\{|x-y|>1\}} (f(y)-f(x))^2 \rho(|x-y|)\,dy\,\mu_V(dx).$$

Taking $\rho(r) = e^{-\delta r} r^{-(d+\alpha)}$ with $0 < \alpha < 2$ and $\delta \geq 0$, we get some conclusions for general fractional Dirichlet forms, which not only complete our recent work [2], but also improve the main result in [1].

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Laplacian Perturbed by Non-Local Operators

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Key words: Laplacian, perturbation, non-local operator, integral kernel, Lévy system, Feller semigroup, martingale problem

Abstract: Suppose that $d \geq 1$ and $0 < \beta < 2$. We establish the existence and uniqueness of the fundamental solution $q^b(t,x,y)$ to non-local operator $\mathcal{L}^b = \Delta + \mathcal{S}^b$, where

$$\mathcal{S}^b f(x) := \int_{\mathbb{R}^d} \left(f(x+z) - f(x) - \nabla f(x) \cdot z \mathbb{1}_{\{|z| \leq 1\}} \right) \frac{b(x,z)}{|z|^{d+\beta}} dz$$

and $b(x,z)$ is a bounded measurable function on $\mathbb{R}^d \times \mathbb{R}^d$ with $b(x,z) = b(x,-z)$ for $x, z \in \mathbb{R}^d$. We show that if $b(x,z) \geq 0$, then $q^b(t,x,y)$ is a strictly positive continuous function and it uniquely determines a conservative Feller process X^b, which has strong Feller property. The Feller process X^b is the unique solution to the martingale problem of $(\mathcal{L}^b, \mathcal{S}(\mathbb{R}^d))$, where $\mathcal{S}(\mathbb{R}^d)$ denotes the space of tempered functions on $\mathbb{R}^d$. Furthermore, sharp two-sided estimates on $q^b(t,x,y)$ are derived.

Some Problems on Riemannian Path and Loop Spaces

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KEY WORDS: Dirichlet form, closability, quasi-regularity, path space, loop space, functional inequality

MATHEMATICAL SUBJECT CLASSIFICATION: 60H07

Abstract: In this talk we shall review some recent results on Riemannian path and loop spaces respectively. We construct a class of Quasi-regular Dirichlet form on path space without additional curvature conditions, and we also obtain a weighted log-Sobolev inequality with respect to the damped O-U Dirichlet form. In particular, Poincare inequality can be derived under some unbounded curvature conditions. In addition, we establish the formula of integration by parts and functional inequalities on free loop space under some conditions.

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Maximum Principles for Parabolic Waldenfels Operators

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KEY WORDS: Parabolic Waldenfels operators, maximum principles, boundary point lemma.

MATHEMATICAL SUBJECT CLASSIFICATION: 60J75; 35B50, 47G20

Abstract: As a sub-class of Lévy type Markov generators, second order (elliptic) Waldenfels operators appear naturally when considering the problem of construction of (in particular jump type) Markov processes with boundary conditions. In this talk, parabolic Waldenfels operators will be introduced. Weak and strong maximum principles as well as the boundary point lemma for such operators will be discussed. The talk is based on a working paper joint with Jinqiao Duan.

Small World Principle of The Real-World Networks

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Key words: random networks; small world effect; Poisson geometry small world; random recursive trees

Mathematical Subject Classification: 60K35, 60K37

Abstract: This talk focuses on the *small world effect* of real world complex networks. By constructing appropriate mathematical models, we search for the underlying causes which make most real world networks small worlds. Note that *small world effect*, the fact that the diameters of most networks are considerably smaller than their siaes, is one of the most important features of real-world complex networks.

Stability and Instability for Switching Jump-Diffusion Processes

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KEY WORDS: Jump-diffusion process, state-dependent switching, order-preserving coupling, almost sure stability, instability, stabilization, destabilization.

MATHEMATICAL SUBJECT CLASSIFICATION: 60J60, 60J27, 93E15.

Abstract: In this talk, we present some almost sure stability criteria for switching jump-diffusion processes with state-dependent switching. By means of introducing certain auxiliary Markov chains and constructing certain order-preserving couplings, upper and lower "stability

envelops" are constructed, which lead to systems with "upper and lower" approximating Markov chains. Using these approximations, sufficient conditions that are relatively easily verifiable for the almost sure stability and instability are obtained. When the jump process is missing, it is demonstrated that the techniques work equally well and provide a way to analyze the corresponding switching diffusion systems with x-dependent switching. In addition, stochastic stabilization and destabilization are examined. Moreover, illustrative examples are provided for demonstration.

Brownian Motion and Thermal Capacity

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KEY WORDS: Brownian motion, thermal capacity, Euclidean and space-time Hausdorff dimension.

MATHEMATICAL SUBJECT CLASSIFICATION: 60J65, 60G17, 28A78, 28A80, 60G15, 60J45.

Abstract: Let W denote d-dimensional Brownian motion. We find an explicit formula for the essential supremum of Hausdorff dimension of $W(E) \cap F$, where $E \subset (0\,, \infty)$ and $F \subset \mathbf{R}^d$ are arbitrary nonrandom compact sets. Our formula is related intimately to the thermal capacity of Watson (1978). We prove also that when $d \geq 2$, our formula can be described in terms of the Hausdorff dimension of $E \times F$, where $E \times F$ is viewed as a subspace of space time.

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Some Nonlinear SPDEs from Measures Valued Processes

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KEY WORDS: Backward stochastic differential equation, stochastic partial differential equation, superprocesses.

MATHEMATICAL SUBJECT CLASSIFICATION: 60H15.

Abstract: In this talk, I will discuss three classes of nonlinear SPDEs arising from the study of continuous state branching processes in random environment. Some techniques developed for the study of these SPDEs will be introduced.

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Exponential Mixing for Retarded Stochastic Differential Equations

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Abstract: n this paper, we discuss exponential mixing property for Markovian semigroups generated by segment processes associated with several class of retarded Stochastic Differential Equations (SDEs) which cover SDEs with constant/variable/distributed time-lags. In particular, we investigate the exponential mixing property for (a) non-autonomous retarded SDEs by the Arzelà–Ascoli tightness characterization of the space $\mathcal{C}$ equipped with the uniform topology (b) neutral SDEs with continuous sample paths by a generalized Razumikhin-type argument and a stability-in-distribution approach and (c) jump-diffusion retarded SDEs by the Kurtz criterion of tightness for the space $\mathcal{D}$ endowed with the Skorohod topology.

Strong Approximations of Reflected SDEs in a Multidimensional General Domain

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Abstract: In this paper, we obtained the strong convergence of Wong-Zakai approximations of reflected SDEs in a general multidimensional domain giving an affirmative answer to this open question.

Heat Kernels and Analyticity of Non-Symmetric Lévy Diffusion Semigroups

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Abstract: Consider the following non-local and non-symmetric Lévy operator: for $\alpha \in (0,2)$,

$$\mathcal{L}^{\kappa}_{\alpha} f(x) := \text{P.V.} \int_{\mathbb{R}^d} (f(x+z) - f(x)) \kappa(x,z) |z|^{-d-\alpha} \mathrm{d}z,$$

where $\kappa(x,z) = \kappa(x,-z)$, $0 < \kappa_0 \leq \kappa(x,z) \leq \kappa_1$ and $|\kappa(x,z) - \kappa(y,z)| \leq \kappa_2 |x-y|^{\beta}$ for some $\beta \in (0,1)$. Using Levi's method, we construct the heat kernel of $\mathcal{L}^{\kappa}_{\alpha}$, and prove the sharp

upper bound, fractional derivative and gradient estimates of the heat kernel. Moreover, we also obtain the analyticity of the non-symmetric semigroup associated with $\mathcal{L}_\alpha^\kappa$ in L^p-spaces provided $p \in [1, \infty)$.

BDSDEs with Polynomial Coefficients

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Abstract: In this paper we study the existence and uniqueness of the $L^{2p}_\rho(R^d; R^1) \times L^2_\rho(R^d; R^d)$ valued solutions of backward doubly stochastic differential equations (BDSDEs) with polynomial growth coefficients using weak convergence, equivalence of norm principle and Wiener-Sobolev compactness arguments. Then we establish a new probabilistic representation of the weak solutions of SPDEs with polynomial growth coefficients through the solutions of the corresponding BDSDEs. This probabilistic representation is then used to prove the existence of stationary solutions of SPDEs on R^d via infinite horizon BDSDEs. The convergence of the solution of a finite horizon BDSDE, when its terminal time tends to infinity, to the solution of the infinite horizon BDSDE is shown to be equivalent to the convergence of the pull-back of the solution of corresponding SPDE to its stationary solution. This way we obtain the stability of the stationary solution naturally. This is a joint work with Qi Zhang.

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The Central Limit Theorems for Markov Processes

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KEY WORDS: Markov processes, central limit theorem, stationary sequences.

MATHEMATICAL SUBJECT CLASSIFICATION: 60F17, 60G10, 62G30.

Abstract: Let $\{X_n\}_{n\geqslant 0}$ be a stationary ergodic Markov chain with state space $(X, \mathcal{B})$ and stationary initial distribution μ. We prove the central limit theorem for an additive functional of the Markov process $\{X_n\}_{n\geqslant 0}$ taking values in $(X, \mathcal{B})$ which is a Polish metric space. The main tools used for proving the central limit theorems are martingale approximations. We also discuss the convergence rates in the central limit theorem.

Support Properties of Λ-Fleming-Viot Processes with Brownian Spatial Motion

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KEY WORDS: Λ-Fleming-Viot process, Λ-coalescent, lookdown construction, Hausdorff dimension

MATHEMATICAL SUBJECT CLASSIFICATION: 60G57

Abstract: Fleming-Viot process is a probability-measure-valued superprocess for population genetics. Roughly, the Λ-Fleming-Viot process is a Fleming-Viot process with general reproduction mechanism. For a class of Λ-Fleming-Viot processes with Brownian spatial motion whose associated Λ-coalescents come down from infinity, we prove the compact support property and identify a one-sided modulus of continuity on propagation of the supports. We also find bounds on Hausdorff dimensions for the support. The lookdown representation of Donnelly and Kurtz [1] for Fleming-Viot process is crucial to our arguments.

This talk is based on Liu and Zhou [2] and Liu and Zhou [3].

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