The 7th International Conference on Random Dynamical Systems

Hanoi, June 21-25, 2022

HANOI, VIETNAM

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The 7th International Conference on Random Dynamical Systems will take place at the Institute of Mathematics, Vietnam Academy of Science and Technology, from 21-25 June, 2022. The conference is devoted to the modern aspects of the theory of random dynamical systems. The aim of the Conference is to bring together active researchers working on various areas of random dynamical systems, stochastic dynamics, stochastic evolution equations, stochastic processes, stochastic computations and their applications for fruitful scientific exchanges on recent advances of the areas, especially bringing together knowledge from various fields of the probability theory and the theory of stochastic processes related to this subject.

Due to the pandemic, the conference will be organized in the hybrid form (both online and offline meetings).

Scientific Committee

— **Jinqiao DUAN**, Illinois Institute of Technology

— **Dinh Cong NGUYEN**, Institute of Mathematics, VAST, Chair

— **Björn SCHMALFUSS**, Friedrich-Schiller- Universität Jena

Organizing Committee

— **Dinh Cong NGUYEN**, Institute of Mathematics, VAST, chair

— **Hoang Duc LUU**, Institute of Mathematics, VAST & MPI for Mathematics in the Sciences, Leipzig, Germany

— **Thai Son DOAN**, Institute of Mathematics, VAST

— **Thanh Hong PHAN**, Thang Long University, Hanoi

— **Thi Thuy Quynh NGUYEN**, Academy of Finance, Hanoi.

Sponsor

- Institute of Mathematics, VAST
- Vietnam Academy of Science and Technology
- International Center for Research and Postgraduate Training in Mathematics under the auspices of UNESCO, Institute of Mathematics, VAST

PROGRAM

Program of the 7th ICRDS

[all times are Hanoi time GMT+7]
[venue: Hoang Tuy Lecture Hall 2^{nd} floor, A6 building, IMH]
[zoom codes of sessions will be sent to online participants by email]

Monday 20 June

18:30-20:30: Reception of international invited speakers (who came to Hanoi) by the director of IMH

Tuesday 21 June

Morning

Registration/ Hanoi city tour for international participants who came to Hanoi

12:00 - 13:30: Lunch for all on-site participants at a local restaurant

Afternoon

Opening ceremony

13:30-13:35: Welcome speech by Prof. Nguyen Dinh Cong

13:35-13:45: Opening remark by Prof. Ludwig Arnold

13:45-13:50: Opening speech by Director of the IMH - Prof. Phung Ho Hai

13:50-14:00: group photo

Opening session (Random dynamical systems) [all times are Hanoi time GMT+7]

Chair: Van Nhung TRAN (VNU University of Science, Hanoi, Vietnam)

14:00 - 14:35 **Ludwig ARNOLD** (University of Bremen, Germany)
A Refinement of the Multiplicative Ergodic Theorem

14:35 – 15:10 **Jinqiao DUAN** (Illinois Institute of Technology, USA)
Recent Advances in Random Dynamical Systems

15:10 - 15:25 **Coffee break**

15:25 - 16:00 **Michael SCHEUTZOW** (Technische Universität Berlin, Germany)
Stabilization and synchronization by noise

16:00 - 16:35 **Thai Son DOAN** (Institute of Mathematics, VAST)
On analyticity of Lyapunov exponent for generic bounded linear random dynamical systems

16:35 - 17:10 **Yuri BAKHTIN** (New York University, USA)
Rare transitions in noisy heteroclinic networks

Wednesday 22 June

Morning session (SDE) [all times are Hanoi time GMT+7]

Chair: Yuri BAKHTIN (New York University, USA)

08:30 - 08:50 **Jianjun Paul TIAN** (New Mexico State University, USA)
Hope bifurcation without parameters in stochastic modeling of cancer virotherapy

08:50 - 09:10 **Vena Pearl BONGOLAN** (UP Diliman, Philippines)
Stochastic Dynamics of Storm Surge with Stable Noise

09:10 - 09:45 **Viet Ton TA** (Kyushu University, Japan)
Stochastic Differential Equation Models for Swarm Behavior

09:45 - 10:20 **Hai Dang NGUYEN** (University of Alabama, USA)
Stability of Coupled Jump Diffusions and Applications

10:20 - 10:35 **Coffee break**

10:35 - 11:10 **Luu Son NGUYEN** (University of Puerto Rico, USA)
Forward-Backward Stochastic Differential Equations with Conditional Mean-Field and Regime Switching and Stochastic Differential Games

11:10 - 11:45 **Hoang Long NGO** (Hanoi National University of Education, Vietnam)
Tamed-Adaptive Euler-Maruyama schemes for long-time approximation of stochastic differential equations with irregular coefficients

11:45 - 12:05 **Rongrong TIAN** (Wuhan University of Technology, China)
Strong solutions of stochastic differential equations with square integrable drift

12:05 - 13:30 Lunch for all on-site participants at a local restaurant

Afternoon session (Rough path theory) [all times are Hanoi time GMT+7]

Chair: Jeroen LAMB (Imperial College London, UK)

13:30 - 14:05 **Yu ITO** (Kyoto Sangyo University, Japan)
A fractional calculus approach to rough path integration

14:05 – 14:40 **Sebastian RIEDEL** (FernUniversität in Hagen, Germany)
Random dynamical systems and rough paths

14:40 - 15:15 **Hoang Duc LUU** (Institute of Mathematics, VAST, Vietnam, and MPI MIS, Leipzig, Germany)
Numerical attractors for rough differential equations

15:15 - 15:30 **Coffee break**

15:30 - 16:05 **Björn SCHMALFUSS** (Friedrich-Schiller-Universität Jena, Germany)
Almost sure averaging for mixed evolution equations

16:05 - 16:25 **Alexandra NEAMTU** (University of Konstanz, Germany)
On the pitchfork bifurcation for the Chafee-Infante equation with additive noise

16:25 - 16:45 **Robert HESSE** (Friedrich-Schiller-Universität Jena, Germany)
Zero-Stability of Rough Evolution Equations

16:45 - 17:05 **Thanh Hong PHAN** (Thang Long University, Hanoi, Vietnam)
Pullback attractors for stochastic Young differential delay equations

17:05 - 17:25 **Caibin ZENG** (South China University of Technology, China)
Random attractors for rough stochastic partial differential equations

Thursday 23 June

Morning session (Stochastics) [all times are Hanoi time GMT+7]

Chair: Hoang Duc LUU (Institute of Mathematics, VAST and MPI MIS, Leipzig, Germany)

08:30 - 09:05	**The Anh CUNG** (Hanoi National University of Education, Vietnam) *On the rate of convergence of the stochastic 2D Navier-Stokes-Voigt equations to the stochastic 2D Navier-Stokes equations with multiplicative noise*
09:05 – 09:40	**Duc Thuan DO** (Hanoi University of Science and Technology, Vietnam) *Stability of singular systems under stochastic perturbations*
09:40 - 10:15	**Zhenxin LIU** (Dalian University of Technology, China) *Averaging principle for monotone SPDEs*
10:15 - 10:30	**Coffee break**
10:30 - 11:05	**Marc PEIGNE** (University of Tours, France) *On critical multi-type branching processes in random environment*
11:05 - 11:40	**Quoc Bao TANG** (Karl-Franzens-University of Graz, Austria) *Stabilisation with boundary noise for partial differential equations*
11:40 - 12:00	**Bin PEI** (Northwestern Polytechnical University, China) *Averaging principle for a fast-slow system driven by mixed fractional Brownian rough path*
12:05 - 13:30	Lunch for all on-site participants at a local restaurant

Afternoon session (SPDE) [all times are Hanoi time GMT+7]

Chair: Björn SCHMALFUSS (Friedrich-Schiller-Universität Jena, Germany)

13:30 - 14:05 **Kening LU** (Brigham Young University, USA)
Ergodicity, mixing, limit theorems for quasi-periodically forced 2D stochastic Navier-Stokes equations

14:05 – 14:40 **Dirk BLÖMKER** (Universität Augsburg, Germany)
Approximate Slow Manifold for stochastic PDEs

14:40 - 15:15 **Nils BERGLUND** (Universite d'Orleans, France)
Stochastic resonance in stochastic PDEs

15:15 - 15:30 **Coffee break**

15:30 - 16:05 **Christian KUEHN** (Technical University of Munich, Germany)
Rough Center Manifolds

16:05 - 16:40 **Xiaopeng CHEN** (Shantou University, China)
An approach to model stochastic systems with observed non-Gaussian data

16:40 - 17:00 **Verena KOEPP** (Friedrich-Schiller-Universität Jena, Germany)
Synchronization of stochastic lattice equations and upper semicontinuity of attractors

17:00 - 17:20 **Matheus MANZATTO DE CASTRO** (Imperial College London, UK)
Existence and uniqueness of quasi-stationary and quasi-ergodic measures for absorbing Markov chains

18:30 - 21:00 **Conference banquet for all on-site participants**

Friday 24 June

Morning session (RDS+) [all times are Hanoi time GMT+7]

Chair: Ale Jan HOMBURG (University of Amsterdam, Netherlands)

08:30 - 09:05	**Cecilia GONZÁLEZ-TOKMAN** (University of Queensland, Australia) *Lyapunov exponents for transfer operator cocycles of metastable maps: a quarantine approach*
09:05 - 09:40	**Jeroen LAMB** (Imperial College London, UK) *Common noise pullback attractors*
09:40 - 10:15	**Hiroki SUMI** (Kyoto University, Japan) *Random Dynamical Systems of Regular Polynomial Maps on* $\mathbb{C}^2$
10:15 - 10:30	**Coffee break**
10:30 - 11:05	**Yuzuru SATO** (Hokkaido University, Japan) *Noise-induced degeneration in online learning*
11:05 - 11:25	**Yubin LU** (Huazhong University of Science and Technology, China) *Data-Driven of Non-Gaussian Stochastic Dynamics: System Learning, Transition Phenomena*
11:25 – 11:45	**Tran Duy VO** (Université de Tours, France) *On recurrence properties of 1-dimensional discrete oscillating random walk*
11:45 - 12:05	**Wei WEI** (Huazhong University of Science & Technology, China) *An Optimal Control Method to Compute the Most Likely Transition Path for Stochastic Dynamical Systems with Jumps*
12:05 - 13:30	Lunch for all on-site participants at a local restaurant

Afternoon session (RDS+) [all times are Hanoi time GMT+7]

Chair: Kening LU (Brigham Young University, USA)

13:30 - 14:05 **Mikhail BULATOV**
(Institute of Systems Dynamics and Control Theory
Siberian Branch of the Russian Academy of Sciences)
Matrix polynomials and their application to high order differential-algebraic equations

14:05 – 14:40 **Peter KLOEDEN** (Goethe University in Frankfurt am Main, Germany)
Dynamical systems representation of Caputo differential equations

14:40 - 15:15 **The Tuan HOANG** (Institute of Mathematics, VAST)
Existence, uniqueness and asymptotic behaviour of solutions to mixed fractional order positive coupled systems with unbounded delays

15:15 - 15:30 **Coffee break**

15:30 - 16:05 **Gary FROYLAND** (University of New South Wales, Australia)
Perturbation formulae for quenched random dynamics with applications to open systems and extreme value theory

16:05 - 16:40 **Marius YAMAKOU**
(Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany)
Transitions between weak-noise-induced resonance in a multiple timescale neural system

16:40 - 17:00 **Guillermo OLICÓN MÉNDEZ** (Freie Universität Berlin, Germany)
Escape rates from almost invariant sets in random maps near a bifurcation point

17:00 - 17:20 **Hugo CHU** (Imperial College London, UK)
The Lyapunov spectrum for conditioned random dynamical systems

Saturday 25 June

Morning session (RDS+) [all times are Hanoi time GMT+7]

Chair: Marc PEIGNE (University of Tours, France)

08:30 - 09:05 **Christian S. RODRIGUES**
(Institute of Mathematics of the University of Campinas, Brazil)
Geometric properties of probability spaces

09:05 - 09:40 **Ale Jan HOMBURG** (University of Amsterdam, Netherlands)
Iterated function systems of linear expanding and contracting maps on the unit interval

09:40 - 10:15 **Tien Dung NGUYEN** (VNU University of Science, Hanoi, Vietnam)
Fisher information and Malliavin calculus

10:15 - 10:30 **Coffee break**

10:30 - 11:05 **Huijie QIAO** (Southeast University, China)
The Onsager-Machlup action functional for Mckean-Vlasov SDEs

11:05 - 11:25 **Ao ZHANG** (Huazhong University of Science and Technology, China)
Effective wave factorization for a stochastic Schrödinger equation

11:25 – 11:45 **Ting GAO** (Huazhong University of Science and Technology, China)
Identifying and learning effective reduced dynamics in non-Gaussian stochastic dynamical systems

11:45 - 12:05 **Thi Huong PHAN** (Le Quy Don Technical University, Hanoi, Vietnam)
Some fundamental properties of solutions of stochastic fractional differential equations

12:05 - 13:30 Lunch for all on-site participants at a local restaurant

Afternoon session (RDS+) [all times are Hanoi time GMT+7]

Chair: Jinqiao DUAN (Illinois Institute of Technology, USA)

13:30 - 14:05 **Jiang-Lun WU** (Swansea University, UK)
Characterising the path-independence of stochastic differential equations: a problem arising in financial modelling

14:05 – 14h25 **Ngoc Huy CHAU** (The University of Manchester, UK)
Robust fundamental theorems of asset pricing in discrete time

14:25 – 14:45 **Wei Hao TEY** (Imperial College London, UK)
Boundary dynamics on minimal invariant sets of random dynamical systems with bounded noise

14:45 – 15:05 **Qiao HUANG** (University of Lisbon, Portugal)
A theory of stochastic geometric mechanics

15:05 – 15:20 **Coffee break**

15:20 – 15:40 **Truong Thanh NGUYEN**
(Hanoi University of Mining and Geology, Vietnam)
Novel finite time optimal guaranteed cost control of uncertain polytopic fractional-order systems with time varying delay

15:40 – 16:00 **Shenglan YUAN** (Universität Augsburg, Germany)
Stochastic bifurcation for two-time-scale dynamical system with α-stable Lévy noise

16:00 – 16:20 **Liubov SOLOVAROVA**
(Matrosov Institute for System Dynamics and Control Theory of SB RAS, Russia)
On the numerical solution of second-order stiff linear differential-algebraic equations

16:20 – 16:40 **Elena CHISTYAKOVA**
(Matrosov Institute for System Dynamics and Control Theory of SB RAS, Russia)
On some issues in numerical treatment of linear higher order differential algebraic equations with singular points

16:40 – 17:00 **Bernat Bassols CORNUDELLA** (Imperial College London, UK)
On the nature of non-uniform synchronisation in a random logistic map

17:00 – 17:10 **Jinqiao DUAN & Dinh Cong NGUYEN**
Closing remarks

Sunday 26 June

One day Halong tour for international guests who came to Hanoi.

ABSTRACTS

A Refinement of the Multiplicative Ergodic Theorem

Ludwig ARNOLD
University of Bremen, Germany

After recalling the concept of a Random Dynamical System (RDS) and quoting Oseledets's Multiplicative Ergodic Theorem (MET) I describe the wealth of problems which was attacked and solved by applying the MET to nonlinear RDS. There is, however, an extension of the MET: The linear classification of random matrices (Jordan normal forms). The problem was treated (and basically solved) by Arnold, Nguyen and Oseledets in 1999 using methods of algebraic ergodic theory. A complete classification of the one- and two-dimensional cases are given. I represent this result to this audience, as, to my opinion, it has not attracted the attention it deserves.

Rare transitions in noisy heteroclinic networks

Yuri BAKHTIN
Courant Institute, New York University, New York, USA

We study small white noise perturbations of planar dynamical systems with heteroclinic networks in the limit of vanishing noise. We show that the probabilities of transitions between various cells that the network tessellates the plane into decay as powers of the noise magnitude, and we describe the underlying mechanism. A metastability picture emerges, with a hierarchy of time scales and clusters of accessibility, similar to the classical Freidlin-Wentzell picture but with shorter transition times. We discuss applications of our results to homogenization problems and to the invariant distribution asymptotics. At the core of our results are local limit theorems for exit distributions obtained via methods of Malliavin calculus.

Joint work with Hong-Bin Chen and Zsolt Pajor-Gyulai.

Stochastic resonance in stochastic PDEs

Nils BERGLUND
Institut Denis Poisson, CNRS, Universite d'Orleans, France

We consider stochastic partial differential equations (SPDEs) on the one-dimensional torus, driven by space-time white noise, and with a time-periodic drift term, which vanishes on two stable and one unstable equilibrium branches. Each of the stable branches approaches the unstable one once per period. We prove that there exists a critical noise intensity, depending on the forcing period and on the minimal distance between equilibrium branches, such that the probability that solutions of the SPDE make transitions between stable equilibria is exponentially small for subcritical noise intensity, while they happen with probability exponentially close to 1 for supercritical noise intensity. Concentration estimates of solutions are given in the H^s Sobolev norm for any $s < \frac{1}{2}$. The results generalise to an infinite-dimensional setting those obtained for 1-dimensional SDEs in [Nils Berglund and Barbara Gentz. A sample-paths approach to noise-induced synchronization: stochastic resonance in a double-well potential. Ann. Appl. Probab., 12(4):1419-1470, 2002].

Joint work with Rita Nader.

Approximate Slow Manifold for stochastic PDEs

Dirk BLÖMKER
Institut für Mathematik, Universität Augsburg, Augsburg, Germany

For a stochastic partial differential equation we approximate the infinite dimensional stochastic dynamics by the motion along a finite dimensional slow manifold. This manifold is deterministic, but not necessarily invariant for the dynamics of the unperturbed equation. Our main results are the derivation of an effective equation (given by a stochastic ordinary differential equations) on the slow manifold, and furthermore the stochastic stability of the manifold in the sense that with probability almost one the solution stay close to the manifold for very long times. This has applications for example to the motion of multiple kinks for the stochastic one-dimensional Cahn-Hilliard equation, the motion of droplets in two- or three dimensional mass-conservative Allen-Cahn or Cahn-Hilliard equation, and also to travelling waves.

Stochastic Dynamics of Storm Surge with Stable Noise

Vena Pearl BONGOLAN
Department of Computer Science, UP Diliman, Philippines

The Advanced Circulation (ADCIRC) and Simulating Nearshore Waves (SWAN) coupled model is modified to include a stochastic term in the shallow water equations. Noise in the fluid velocity can come from debris carried by surge or from short-term local scale atmospheric fluctuations. To incorporate random external forces and account for measurement errors on data, modification of an existing model is needed. We added alpha- stable processes, uncorrelated in space-time as noise terms in the numerical solution of ADCIRC and SWAN coupled model. Relevant inputs to the model were unstructured computational grid derived from topography and bathymetry, tidal potential constituents, land cover classification and atmospheric forcing. Simulation results were validated with storm surge phenomena in Tacloban City during the landfall of Typhoon Haiyan on November 2013 based on field surveys. The model simulated surge height of around 5 meters rushing at 4 meters per second near Tacloban City downtown. It was also used to simulate storm surge during the landfall of typhoon Hagupit on December 2014 at Casab- Ahan, Daram, Samar to validate field observations. Simulated surge height was around 1.1 meters rushing at 0.8 meters per second. Underestimation of modeled peak heights is expected with use of bare earth model, absence of precipitation, river overflows and other fluid sources on the governing equations. To investigate the effects of noise with respect to the deterministic model different parameter values were assigned. As index of stability goes to zero larger jumps occur more frequently so variance needs to be as small as $10^{(-8)}$ for simulation stability. Major results are: the stochastic model is sensitive in detecting fast flows, and opposing directions of tide and surge, as what happens at low tide. The difference of stochastic solutions from deterministic solution averages to zero and there is no improvement of the storm surge model when it comes to additive noise; an expected result since noise has zero mean

This is a joint work with Joshua Frankie Rayo.

Matrix polynomials and their application to high order differential-algebraic equations

Mikhail BULATOV

Matrosov Institute for System Dynamics and Control Theory of SB RAS, Irkutsk, Russia

The report deals with matrix polynomials of degree k depending on the argument. The matrices are assumed to be square. The main attention is paid to the case when the matrix in front of the highest degree is not zero, but is identically degenerate. The concept of matrix polynomials of simple structure is introduced and their properties are studied. As an application, the result of the analysis of high-order linear differential-algebraic equations is given. Sufficient conditions for the existence of a unique solution for such systems are formulated. Examples are given. Research was supported by Russian Science Foundation, grant No. 22-11-00173, https://rscf.ru/project/22-11-00173/

This is a joint work with Solovarova Liubov.

Robust fundamental theorems of asset pricing in discrete time

Ngoc Huy CHAU

Department of Mathematics, University of Manchester, UK

This talk is devoted to the study of robust fundamental theorems of asset pricing in discrete time and finite horizon settings. The new concept "robust pricing system" is introduced to rule out the existence of model independent arbitrage opportunities. Superhedging duality and strategy are obtained.

An approach to model stochastic systems with observed non-Gaussian data

Xiaopeng CHEN

College of Science, Shantou University, China

We propose an approach to estimate the stochastic systems based on discrete non-Gaussian observations. Since the closed-form expression of maximum likelihood function is hard to obtain in the Lévy case, we choose a mixture of Cauchy and Gaussian distribution to approximate the probability density function (PDF) of the S distribution. By means of transition function and Laplace transform, we construct an explicit approximate sequence of likelihood function, which converges to the likelihood function of S distribution. Based on the approximation of likelihood function we give an algorithm for computing maximum likelihood estimation. We also numerically simulate some experiments which demonstrate the accuracy and stability of the proposed algorithm.

On some issues in numerical treatment of linear higher order differential algebraic equations with singular points.

Elena CHISTYAKOVA

Institute for System Dynamics and Control Theory of Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia

Modeling of various technical and natural processes often results in systems that comprise ordinary differential equations of different orders and algebraic equations. Such systems are commonly referred to as differential algebraic equations (DAEs). In this talk, we make an attempt to formalize the notion of singular points for DAEs, classify them and propose ways for finding them in the domain of a particular DAE. We also consider possible methods for numerical treatment of DAEs with singular points.

Joint work with Viktor Chistyakov.

The Lyapunov spectrum for conditioned random dynamical systems

Hugo CHU

Imperial College London, UK

Markov processes conditioned on remaining in certain domain have been well-studied from a statistical point of view but their dynamical properties are so far not well-understood. In this talk, we show that for a large class of random dynamical systems under such conditioning, the Lyapunov exponents are well-defined. Finally, we show how these can be applied to study the pitchfork bifurcation driven by additive noise.

This is joint work with Matheus De Castro, Martin Rasmussen, Jeroen S. W. Lamb (Imperial College London) and Dennis Chemnitz, Maximilian Engel (Freie Universität Berlin).

On the nature of non-uniform synchronisation in a random logistic map

Bernat Bassols CORNUDELLA

Imperial College London, UK

We apply novel results in quasi-ergodic theory to a compartmental model of the random logistic map with additive noise, allowing us to describe hidden transient dynamics, and providing us with more detailed information of the system's explicit synchronising behaviour. In particular, we compute the conditioned Lyapunov exponents on each region of a tailored partition of the phase space and provide the first quantitative analysis of transient dynamics, key in the understanding of noise-induced phenomena.

On the rate of convergence of the stochastic 2D Navier-Stokes-Voigt equations to the stochastic 2D Navier-Stokes equations with multiplicative noise

The Anh CUNG

Faculty of Mathematics and Informatics, Hanoi National University of Education, Vietnam

We study the convergence of the solution of the stochastic 2D Navier-Stokes-Voigt equations to the corresponding solution of the stochastic 2D Navier-Stokes equations. We are mainly interested in the rate, as $\alpha \to 0$, of the following error function

$$\varepsilon_\alpha(t) = \sup_{s\in[0,t]} |u^\alpha(s) - u(s)| + \left(\int_0^t \|u^\alpha(s) - u(s)\|^2 \, ds \right)^{\frac{1}{2}},$$

where u^α and u are the solutions of stochastic Navier-Stokes-Voigt equations and the stochastic Navier-Stokes equations, respectively. We prove that ε_α converges in mean square and in probability to 0 with order at most $O(\alpha)$.

Stability of singular systems under stochastic perturbations

Duc Thuan DO

School of Applied Mathematics and Informatics, Hanoi University of Science and Technology, Vietnam

In this talk, we will present some problems about stability of singular systems under stochastic perturbations. These systems are models arising in some applications such as electrical circuit simulation, multibody systems, control theory, economics.... Firstly, we introduce the index concept and establish a formula of solution for singular systems described by stochastic differential-algebraic equations (SDAEs). After that the stability of SDAEs is studied and formulas of the stability radii are derived for these systems. Secondly, we shall deal with stochastic singular difference equations (SSDEs) with constant coefficient matrices under stochastic nonlinear perturbations and stochastic delay perturbations. An index concept is derived and solvability are investigated for these equations. The stability of SSDEs is studied by using the method of Lyapunov functions and comparison principle.

On analyticity of Lyapunov exponent for generic bounded linear random dynamical systems

Thai Son DOAN

Institute of Mathematics, VAST, Vietnam

We construct an open and dense set in the space of bounded linear random dynamical systems (both discrete and continuous time) equipped with the essential sup norm such that the Lyapunov exponents depend analytically on the coefficients in this set. As a consequence, analyticity for Lyapunov exponents of bounded linear random dynamical systems is a generic property.

This is a joint work with Nguyen Dinh Cong.

Recent Advances in Random Dynamical Systems

Jinqiao DUAN

Laboratory for Stochastic Dynamics & Computation, Illinois Institute of Technology, USA

Complex dynamical systems are often under random fluctuations. The noisy fluctuations may be Gaussian or non-Gaussian, which are usually modeled by Brownian motion or α-stable Levy motion, respectively. Stochastic differential equations are appropriate mathematical models for these systems.

The speaker will present some recent advances in theoretical and applied aspects of random dynamical systems. The theoretical issues include geometric, analytical and probabilistic approaches for examining random dynamical behaviors, while applied topics involve with investigating random phenomena in physical, geophysical or biophysical systems.

Perturbation formulae for quenched random dynamics with applications to open systems and extreme value theory

Gary FROYLAND

School of Mathematics and Statistics, University of New South Wales, Australia

We consider quasi-compact linear operator cocycles $\mathcal{L}_\omega^n := \mathcal{L}_{\sigma^{n-1}\omega} \circ \cdots \circ \mathcal{L}_{\sigma\omega} \circ \mathcal{L}_\omega$ driven by an invertible ergodic process $\sigma : \Omega \to \Omega$, and their small perturbations $\mathcal{L}_{\omega,\epsilon}^n$.

We prove an abstract ω-wise first-order formula for the leading Lyapunov multipliers $\lambda_{\omega,\epsilon} = \lambda_\omega - \theta_\omega \Delta_{\omega,\epsilon} + o(\Delta_{\omega,\epsilon})$, where $\Delta_{\omega,\epsilon}$ quantifies the closeness of $\mathcal{L}_{\omega,\epsilon}$ and $\mathcal{L}_\omega$.

We then consider the situation where $\mathcal{L}_\omega^n$ is a transfer operator cocycle for a random map cocycle $T_\omega^n := T_{\sigma^{n-1}\omega} \circ \cdots \circ T_{\sigma\omega} \circ T_\omega$ and the perturbed transfer operators $\mathcal{L}_{\omega,\epsilon}$ are defined by the introduction of small random holes $H_{\omega,\epsilon}$ in $[0, 1]$, creating a random open dynamical system.

We obtain a first-order perturbation formula in this setting, which reads $\lambda_{\omega,\epsilon} = \lambda_\omega - \theta_\omega \mu_\omega(H_{\omega,\epsilon}) + o(\mu_\omega(H_{\omega,\epsilon}))$, where μ_ω is the unique equivariant random measure (and equilibrium state) for the original closed random dynamics.

Our new machinery is then deployed to create a spectral approach for a quenched extreme value theory that considers random dynamics with general ergodic invertible driving, and random observations.

An extreme value law is derived using the first-order terms θ_ω.

Finally, in the setting of random piecewise expanding interval maps, we establish the existence of random equilibrium states and conditionally invariant measures for random open systems via a random perturbative approach.

This is joint work with Jason Atnip, Cecilia Gonzalez-Tokman, and Sandro Vaienti

Identifying and learning effective reduced dynamics in non-Gaussian stochastic dynamical systems

Ting GAO

Center for Mathematical Science, Huazhong University of Science and Technology, China

In this talk, I will talk about deep learning algorithms in non-Gaussian stochastic dynamical systems. Especially identifying unknown functions for non-Gaussian stochastic dynamical systems, learning the slow manifold and effective reduced dynamics on it.

Lyapunov exponents for transfer operator cocycles of metastable maps: a quarantine approach

Cecilia GONZÁLEZ-TOKMAN

School of Mathematics and Physics, University of Queensland, Australia

We investigate the Lyapunov-Oseledets spectrum of transfer operator cocycles associated to a class of random metastable maps, indexed by a parameter ϵ, quantifying the strength of the leakage between two nearly invariant regions. We show that the system exhibits metastability, and identify the second Lyapunov exponent λ_2^ϵ within an error of order $\epsilon^2 \log \frac{1}{\epsilon}$. We show this approximation agrees with the naive prediction provided by a time-inhomogeneous two-state Markov chain. Furthermore, we show that $\lambda_1^\epsilon = 0$ and λ_2^ϵ are simple, and the only exceptional Lyapunov exponents of magnitude greater than $-\log 2 + O(\log\log \frac{1}{\epsilon} / \log \frac{1}{\epsilon})$.

Joint work with Anthony Quas.

Zero-Stability of Rough Evolution Equations

Robert HESSE

Friedrich-Schiller-Universität Jena, Germany

In this talk we consider parabolic stochastic evolution equations driven by multiplicative noise given by a fractional Brownian motion with Hurst parameter $H \in (\frac{1}{3}, \frac{1}{2}]$. By constructing a rough path from the noise it is possible to interpret these SPDEs as rough PDEs which can be solved under suitable conditions on the parameters. Consequently, the fact that the solution of the SPDE generates a random dynamical system follows naturally. Based on this we analyze the long-time behavior of rough parabolic equations. More precisely, we consider the mild formulation and show the exponential stability of the trivial solution in a dissipative setting.

Iterated function systems of linear expanding and contracting maps on the unit interval

Ale Jan HOMBURG

Korteweg-de Vries Institute for Mathematics, University of Amsterdam, Netherlands

We consider iterated function systems on the unit interval generated by expanding and contracting affine maps. In this toy model we analyze the interaction of expansion and contraction by studying the dynamics of multiple orbits together. This is done using the iterated function system generated by the two-point maps. Depending on the Lyapunov exponent we encounter phenomena of synchronization, intermittency, and expansion.

This is joint work with Charlene Kalle.

Existence, uniqueness and asymptotic behaviour of solutions to mixed fractional order positive coupled systems with unbounded delays

The Tuan HOANG

Institute of Mathematics, VAST

This paper is devoted to discussing some important problems in the qualitative theory of mixed fractional order positive coupled systems with unbounded delays. In particular, we study the existence, uniqueness, positivity and describe the asymptotic behavior of solutions to these systems.

This report is based on the results of joint work with La Van Thinh.

A theory of stochastic geometric mechanics

Qiao HUANG

University of Lisbon, Portugal

In this talk, we shall introduce a framework of stochastic geometric mechanics based on second-order differential geometry. We will establish stochastic Lagrangian and Hamiltonian mechanics, as well as their key relations with the second-order Hamilton-Jacobi-Bellman equation. The inspirational example, along the talk, will be the rich dynamical structure of diffusion bridges and Schrödinger's problem in optimal transport, where the latter is also regarded as an Euclidean version of hydrodynamical interpretation of quantum mechanics.

A fractional calculus approach to rough path integration

Yu ITO

Faculty of Science, Kyoto Sangyo University, Japan

Using fractional calculus, Y. Hu and D. Nualart (2009) introduced an alternative approach to the fundamental theory of rough path analysis. A purpose of the speaker's study is to develop the approach by Hu and Nualart (2009). In this talk, using fractional calculus, we will introduce an approach to the rough path integral introduced by M. Gubinelli (2004). Our definition of the integral is given explicitly by the Lebesgue integrals for fractional derivatives. We will show that our definition of the integral is consistent with the usual definition, given by the limit of the compensated Riemann-Stieltjes sums. We will also explain that this result provides such an explicit expression of the rough path integral introduced by T. J. Lyons (1998). Our result is a generalization of that of Hu and Nualart (2009), and our proof is based on a method by M. Zähle (1998).

Dynamical systems representation of Caputo differential equations

Peter KLOEDEN

Institute of Computer Science and Mathematics,
Goethe University in Frankfurt am Main, Germany

It is known from the work of Cong and Tuan that higher dimensional Caputo differential equations, both deterministic and stochastic, do not generate a semigroup /cocycle in their state space. They do form a special class of Volterra integral equations with an integrable singular kernel, so work of Sell can be used to show that they do generate a semigroup /cocycle in an appropriate function space this will be described here. The existence of attractors will also be discussed for dissipative vector fields.

Synchronization of stochastic lattice equations and upper semicontinuity of attractors

Verena KOEPP

Institut für Mathematik, Friedrich-Schiller-Universität Jena, Germany

In this talk we consider a system of two coupled stochastic lattice equations driven by additive white noise processes. When the intensity of the coupling gets large, we observe that the system synchronizes in a certain sense. To describe this phenomenon we prove the upper semicontinuity of the corresponding family of random attractors with respect to the random attractor of a specific limiting system.

This is joint work with H. Bessaih, M.J. Garrido Atienza and B. Schmalfuss.

Rough Center Manifolds for SODEs

Christian KUEHN

Faculty of Mathematics, Technical University of Munich, Germany

In this talk, I am going to explain an approach to construct rough center manifolds for SODEs using rough path theory.

This is joint work with Alexandra Neamtu.

Common noise pullback attractors

Jeroen S.W. LAMB

Department of Mathematics, Imperial College London, England

We consider SDEs driven by two different sources of additive noise, which we refer to as intrinsic and common. We establish almost sure existence and uniqueness of pullback attractors with respect to realisations of the common noise only. These common noise pullback attractors are smooth probability densities that depend only on (the past of) a common noise realisation and to which the pullback evolution of a corresponding stochastic Fokker-Planck equation converges. Common noise pullback attractors have a natural motivation in the context of particle systems with intrinsic and common noise, describing the distribution of the system conditioned on (the past of) a common noise realisation. We also discuss some (potential) applications.

This is joint work with Federico Graceffa.

Averaging principle for monotone SPDEs

Zhenxin LIU

School of Mathematical Sciences, Dalian University of Technology, China

The first Bogolyubov theorem on averaging for SDEs has been investigated extensively. In this talk, we will discuss the second Bogolyubov theorem and global averaging principle for monotone SPDEs.

This talk is based on our joint work with Mengyu Cheng.

Ergodicity, mixing, limit theorems for quasi-periodically forced 2D stochastic Navier-Stokes Equations

Kening LU

Department of Mathematics, Brigham Young University, USA

We consider the incompressible 2D Navier-Stokes equations on the torus driven by a deterministic time quasi-periodic force and a noise that is white in time and extremely degenerate in Fourier space. We show that the asymptotic statistical behavior is characterized by a uniquely ergodic and exponentially mixing quasi-periodic invariant measure. The result is true for any value of the viscosity $\nu > 0$. By utilizing this quasi-periodic invariant measure, we show the strong law of large numbers and central limit theorem for the continuous time inhomogeneous solution processes. Estimates of the corresponding rate of convergence are also obtained, which is the same as in the time homogeneous case for the strong law of large numbers, while the convergence rate in the central limit theorem depends on the Diophantine approximation property on the quasi-periodic frequency and the mixing rate of the quasi-periodic invariant measure. We also prove the existence of a stable quasi-periodic solution in the laminar case (when the viscosity is large).

This talk is based on a joint work with Liu Rongchang.

Data-Driven of Non-Gaussian Stochastic Dynamics: System Learning, Transition Phenomena

Yubin LU

School of Mathematics and Statistics, Huazhong University of Science and Technology, China

In this talk, we will introduce two aspects of data-driven analysis of non-Gaussian stochastic dynamics, i.e., extracting stochastic governing laws and estimating transition probability density. To be specific, on one hand, we will show how to learn a stochastic differential equation with Levy noise from data. On the other hand, we will present how to estimate the evolution of the transition probability density from sample path data. Some numerical results will also be introduced.

Numerical attractors for rough differential equations

Hoang Duc LUU

Institute of Mathematics, VAST, Vietnam and MPI MIS, Leipzig, Germany

We study the explicit Euler scheme to approximate the solutions of rough differential equations under a bounded or linear diffusion term, where the drift term satisfies a local Lipschitz continuity and a bounded linear growth condition. The Euler scheme is then proved to converge for a given solution, although the approximation of the error depends on the initial condition. For a dissipative drift term with linear growth condition and a bounded diffusion term, the numerical solution under a regular grid generates a random dynamical system which admits a random pullback attractor. We also prove that for bounded drift and diffusion terms, the numerical pullback attractor then converges upper semi-continuously to the continuous-time pullback attractor as the time step goes to zero.

Joint work with Peter Kloeden.

Existence and uniqueness of quasi-stationary and quasi-ergodic measures for absorbing Markov chains

Matheus MANZATTO DE CASTRO

Imperial College London, UK

A central question on absorbing Markov processes concerns the existence and uniqueness of quasi-stationary and quasi-ergodic measures, but sufficient conditions have remained quite restrictive in a general context. In this talk, we motivate and establish the existence and uniqueness of quasi-stationary and quasi-ergodic measures for almost surely absorbed-time Markov processes under mild conditions on evolution.

This is joint work with Martin Rasmussen, Jeroen S. W. Lamb (Imperial College London) and Guillermo Olicón Méndez (Freie Universitäät Berlin).

On the pitchfork bifurcation for the Chafee-Infante equation with additive noise

Alexandra NEAMTU

University of Konstanz, Germany

Detecting bifurcation points for SPDEs is a subtle task, because even for nite-dimensional stochastic systems the question of how to describe a bifurcation is not fully answered. Here we investigate pitchfork bifurcations for a stochastic reaction diusion equation perturbed by an innite-dimensional Wiener process. It is well-known that the random attractor is a singleton, independently of the value of the bifurcation parameter; this phenomenon is often referred to as the destruction of the bifurcation by the noise. Analogous to the results of [Callaway et al., AIHP Probab. Stat., 53:1548-1574, 2017] for a 1D stochastic ODE, we show that some remnant of the bifurcation persists for this SPDE model in the form of a positive nite-time Lyapunov exponent. Additionally, we prove nite-time expansion of volume with increasing dimension as the bifurcation parameter crosses further eigenvalues of the Laplacian.

This talk is based on a joint work with Alex Blumenthal and Maximilian Engel.

Tamed-Adaptive Euler-Maruyama schemes for long-time approximation of stochastic differential equations with irregular coefficients

Hoang Long NGO

Faculty of Mathematics and Informatics, Hanoi National University of Education, Vietnam

We consider the numerical approximation for Lévy-driven stochastic differential equations whose drift and diffusion coefficients are locally Lipschitz and of super-linear growth. We propose a tamed-adaptive Euler-Maruyama approximation scheme that converges at the rate of order 1/2 on any finite time interval. Moreover, under a sufficient condition for the stability of the exact solution in L^p-norm, we show that the approximate solution also converges at the same rate of order 1/2 uniformly on the whole time interval $[0, +\infty)$.

This talk is based on several joint works with Tran Ngoc Khue, Luong Duc Trong, and Kieu Trung Thuy.

Stability of Coupled Jump Diffusions and Applications

Hai Dang NGUYEN

Department of Mathematics, University of Alabama, USA

This work develops stability and stabilization results for systems of fully coupled jump diffusions. Such systems frequently arise in numerous applications where each subsystem (component) is operated under the influence of other subsystems (components). We derive sufficient conditions under which the underlying coupled jump diffusion is stable. The results are then applied to investigate the stability of linearizable jump diffusions, fast-slow coupled jump diffusions. Moreover, weak stabilization of interacting systems and consensus of leader-following systems are examined.

Forward-Backward Stochastic Differential Equations with Conditional Mean-Field and Regime Switching and Stochastic Differential Games

Luu Son NGUYEN

Department of Mathematics, University of Puerto Rico, USA

In this talk, we first study forward-backward stochastic differential equations with regime switching. Then we focus on forward-backward stochastic differential equations with mean-field interactions and regime-switching. We obtain conditions for the existence and uniqueness of such equations without assuming the non-degenerate condition for the forward equation. The results are then applied to investigate the problem of existence of open-loop Nash equilibrium points for nonzero sum linear-quadratic stochastic differential games with random coefficients.

Keywords: switching diffusion, mean-field interaction, forward-backward stochastic differential equations, stochastic differential games

This is a joint work with Esteban Rolon Gutierrez and George Yin.

Fisher information and Malliavin calculus

Tien Dung NGUYEN
VNU University of Science, Hanoi, Vietnam

We provide an explicit estimate for the Fisher information distance of a Malliavin differentiable random variable to the standard normal distribution. The result is illustrated by the normalized solutions of stochastic differential equations with small noise.

Novel finite time optimal guaranteed cost control of of uncertain polytopic fractional-order systems with time varying delay

Truong Thanh NGUYEN
Hanoi University of Mining and Geology, Vietnam

This paper deals with the problem of finite time optimal guaranteed cost control for uncertain polytopic fractional-order systems with time varying delay. A linear quadratic cost function is considered as a performance measure for the closed-loop system. By using Laplace transform and linear matrix inequalities, a guaranteed cost controller design is presented and sufficient conditions for the existence of a finite time guaranteed cost state-feedback for the system are given in terms of LMIs. A numerical example is given to illustrate the effectiveness of the obtained result.

Escape rates from almost invariant sets in random maps near a bifurcation point

Guillermo OLICÓN MÉNDEZ
Freie Universität Berlin, Germany

In this talk we consider one-dimensional continuously differentiable maps perturbed with additive bounded noise. These systems may exhibit topological bifurcations, which are discontinuous changes of the minimal invariant sets. We show that when this qualitative change is induced by a nondegenerate saddle-node bifurcation of the so-called extremal maps, then beyond but close

to the bifurcation the system tends to remain for long times in those sets that used to be invariant just before the bifurcation occured. In particular, we show these sets admit a unique quasi-stationary distribution. Furthermore, we give asymptotic universal bounds for the escape rates which depend only on the geometrical features of the extremal maps.

This is joint work with Jeroen S.W. Lamb and Martin Rasmussen (Imperial College London).

Averaging principle for a fast-slow system driven by mixed fractional Brownian rough path

Bin PEI

School of Mathematics and Statistics, Northwestern Polytechnical University, China

This paper is devoted to studying the averaging principle for a fast-slow system of rough differential equations driven by mixed fractional Brownian rough path. The fast component is driven by Brownian motion, while the slow component is driven by fractional Brownian motion with Hurst index H ($\frac{1}{3} < H \leq \frac{1}{3}$). Combining the fractional calculus approach to rough path theory and Khasminskii's classical time discretization method, we prove that the slow component strongly converges to the solution of the corresponding averaged equation in the L1-sense. The averaging principle for a fast-slow system in the framework of rough path theory seems new.

Joint work with Y. Inahama and Y. Xu.

On critical multi-type branching processes in random environment

Marc PEIGNE

University of Tours, France

We consider a critical multi-type branching processes in i.i.d. random environment and study the speed of convergence to 0 of the survival probability of this process. This study relies on some recent results on uctuations of products of positive random matrices.

We will present the context of the problem, firstly in for one type branching processes in fixed environment, and recall some known results on product of random matrices and their uctuations. We will state the main theorem we have obtained and detail the strategy of the proof.

This result is a joint work with E. Le Page and T.D.C Pham. We will conclude with some recent improvement, works in progress by T.D.C. Pham

Pullback attractors for stochastic Young differential delay equations

Thanh Hong PHAN

Thanglong University, Hanoi, Vietnam

We study the asymptotic dynamics of stochastic Young differential delay equations under the regular assumptions on Lipschitz continuity of the coefficient functions. Our main results show that, if there is a linear part in the drift term which has no delay factor and has eigenvalues of negative real parts, then the generated random dynamical system possesses a random pullback attractor provided that the Lipschitz coefficients of the remaining parts are small.

Joint work with N. D. Cong and L. H. Duc

Some fundamental properties of solutions of stochastic fractional differential equations

Thi Huong PHAN

Le Quy Don Technical University, Hanoi, Vietnam

In the first part of this talk, we present some fundational properties of solutions of stochastic fractional differential equations including the existence and uniqueness and the regularity. The second part is devoted to presenting some numerical methods for the solutions of stochastic fractional differential equations.

This is a joint work with T. S. Doan, P. E. Kloeden, H. T. Tuan and V. A. My.

The Onsager-Machlup action functional for Mckean-Vlasov SDEs

Huijie QIAO
School of Mathematics, Southeast University, China

This paper is devoted to deriving the Onsager-Machlup action functional for Mckean-Vlasov stochastic differential equations in a class of norms that dominate $L^2([0,1],\mathbb{R}^d)$, such as supremum norm $\|\cdot\|_\infty$, Hölder norms $\|\cdot\|_\alpha$ with $\alpha < \frac{1}{4}$ and L^p-norms with $p > 4$ are included. Moreover, the corresponding Euler-Lagrange equation for Onsager-Machlup action functional is derived and an example is given.

Random dynamical systems and rough paths

Sebastian RIEDEL
FernUniversität in Hagen, Germany

Rough paths theory allows solving stochastic (ordinary or partial) differential equations (SDE) pathwise. This makes the theory very useful when studying SDEs with random dynamical systems (RDS): if there is a rough path interpretation of the equation, it is almost immediate that the equation induces a cocycle. As an example, we consider stochastic delay differential equations. Although these equations were often presented as examples where the theory of RDS does not apply, we show that a rough path interpretation of the equation provides a way to use RDS to study their long-time behavior.

Joint work with Mazyar Ghani Varzaneh (FU Hagen) and Michael Scheutzow (TU Berlin).

Geometric properties of probability spaces

Christian S. RODRIGUES
Institute of Mathematics of the University of Campinas, Brazil

The study of stability of Dynamical Systems from different perspectives is currently present in almost all fields of science. From the statistical point of view, one wants to infer asymptotic behaviour in deterministic as well as in

random dynamics. Although key statistical properties of the dynamics may depend on the geometry of the space in place, very little geometric information is taken into account while studying the properties of probability spaces which encodes ergodic properties. In particular, intrinsic geometric properties of the probability spaces are very often neglected. In this talk we shall address some geometric properties of probability spaces and investigate how they are related to statistical properties of dynamical systems.

This is a joint work with Renata Possobon.

Noise-induced degeneration in online learning

Yuzuru SATO

Department of Mathematics, Faculty of Science, Hokkaido University, Japan

In order to elucidate the plateau phenomena caused by vanishing gradient, we herein analyse stability of stochastic gradient descent near degenerated subspaces in a multi-layer perceptron. In stochastic gradient descent for Fukumizu-Amari model, which is the minimal multi-layer perceptron showing non-trivial plateau phenomena, we show that (1) attracting regions exist in multiply degenerated subspaces, (2) a strong plateau phenomenon emerges as a noise-induced synchronisation, which is not observed in deterministic gradient descent, (3) an optimal fluctuation exists to minimise the escape time from the degenerated subspace. The noise-induced degeneration observed herein is expected to be found in a broad class of machine learning via neural networks.

Stabilization and synchronization by noise

Michael SCHEUTZOW

Fakultät II, Institut für Mathematik, Technische Universität Berlin, Germany

We discuss the change of stability behavior of deterministic dynamical systems in Euclidean space under the addition of white noise. It is known that noise can have a stabilizing or destabilizing effect depending on the underlying system. We focus on examples of dynamical system in the plane which exhibit blow-up in finite time for all or almost all initial conditions such that for additive noise of arbitrarily small intensity the system has strong stability properties: it is not only stable in the sense that it does not blow up but it even admits a

random set attractor. Parts of the talk are based on joint work with Matti Leimbach (Berlin) and Jonathan Mattingly (Duke, Durham), another part on joint work with Franco Flandoli (Pisa) and Benjamin Gess (Bielefeld) and yet another part on joint work with Isabell Vorkastner (Berlin).

Almost sure averaging for mixed evolution equations

Björn SCHMALFUSS

Friedrich-Schiller-Universität Jena, Germany

We consider a coupled system consisting of two evolution equations. One of these equations is driven by a fractional Brownian motion ($H > \frac{1}{2}$) and the other by a Brownian motion which is scaled by a time parameter. Sending this parameter to zero we obtain the almost sure convergence of the first equation to an equation with an averaged coefficient. We apply the theory of random fixed points.

Joint work with B. Pei.

On the numerical solution of second-order stiff linear differential-algebraic equations

Liubov SOLOVAROVA

Matrosov Institute for System Dynamics and Control Theory of SB RAS, Irkutsk, Russia

The report addresses systems of linear ordinary differential equations with an identically degenerate matrix in front of the main part of the second order. On the basis of facts from the theory of matrix pencils and polynomials, sufficient conditions for the existence and uniqueness of the solution of these equations are given. To solve them numerically, a multistep method and its version based on a reformulated notation of the original problem are investigated. This representation makes it possible to construct methods whose coefficient matrices can be calculated at previous points. This approach has delivered good results in the numerical solution of first-order differential-algebraic equations containing stiff and rapidly oscillating components and in which the matrix pencil is singular. The numerical algorithm proposed in this work is investigated for stability for the well-known test equation. It is shown that this difference scheme has the first order of convergence. Numerical calculations of the model problem are presented.

This is joint work with Ta Duy Phuong.

Random Dynamical Systems of Regular Polynomial Maps on $\mathbb{C}^2$

Hiroki SUMI

Graduate School of Human and Environmental Studies, Kyoto University, Japan

We introduce the notion of mean stability in i.i.d. random (holomorphic) 2-dimensional dynamical systems. We can see that a generic random dynamical system of regular polynomial maps on $\mathbb{P}^2$ (the complex 2-dimensional projective space) having an attractor in the line at infinity is mean stable. If a random holomorphic dynamical system on $\mathbb{P}^2$ is mean stable then for each z in $\mathbb{P}^2$, for a.e. orbit starting with z, the Lyapunov exponent is negative.

If a random holomorphic dynamical system on $\mathbb{P}^2$ is mean stable, then for any z in $\mathbb{P}^2$, the orbit of the Dirac measure at z under the iterations of the dual map of the transition operator converges to a periodic cycle of probability measures. Note that the above statements cannot hold for deterministic dynamics of a single regular polynomial map f of degree two or more.

We see many randomness-induced phenomena (phenomena in random dynamical systems which cannot hold for iteration dynamics of single maps). In this talk, we see randomness-induced order.

Stochastic Differential Equation Models for Swarm Behavior

Ton Viet TA

Faculty of Agriculture, Kyushu University, Japan

This talk presents some models of stochastic differential equations for swarm behavior in: 1) free space, 2) space having obstacles, 3) space having food, and 4) space having predator. The numerical results obtained from the models will be presented. They include geometrical structure, cohesiveness, obstacle-avoiding patterns, and predator-avoiding patterns.

Stabilisation with boundary noise for partial differential equations

Quoc Bao TANG

Institute of Mathematics and Scientific Computing, Karl-Franzens-University of Graz, Austria

The stabilisation by noise has been noticed and studied since decades. Roughly speaking, this seemingly counter-intuitive phenomenon asserts that the noise mixes the unstable and stable directions in a suitable way to eventually drive the system to a stable state. The problem has been studied extensively in case of "global noise", i.e. the noise is acting on the whole domain. In this talk, I discuss the case where the noise is acting only on the boundary of the domain for a Chafee-Infante equation with dynamical boundary conditions. It is shown that, in certain situations, we are able to stabilise the system using boundary noise. Interestingly, it seems that when the system is "too much" unstable, such a stabilisation by boundary noise is not possible, which is in sharp contrast with the case of "global noise". This speculation is numerically confirmed by simulation.

This is based on a joint work with Klemens Fellner, Stefanie Sonner, and Do Duc Thuan.

Boundary dynamics on minimal invariant sets of random dynamical systems with bounded noise

Wei Hao TEY

Imperial College London, UK

The theory of dynamical systems is pivotal in real-world applications ranging from computer algorithms to weather prediction. Realistically, there exists uncertainties or random noises, which translated to the study of random dynamical systems. Consider a discrete-time dynamical system with bounded noise where it can be represented by a set-valued mapping. We are interested in changes in the minimal invariant sets under these set-valued mappings. In this talk, we investigate their boundary dynamics which would help in detecting discontinuous changes of the sets. We then look at simple examples of linear maps with bounded noise where the minimal invariant sets are generally nontrivial.

Hope bifurcation without parameters in stochastic modeling of cancer virotherapy

Jianjun Paul TIAN

Department of Mathematical Sciences, New Mexico State University, USA

Based on our previous PDE model about oncolytic virotherapy, we propose an ODE model which incorporates both innate and adaptive immune responses, and Ito SDE model which incorporates microenvironmental noises from immune systems. We conducted analysis of the models. The deterministic model undergoes Hopf bifurcation without parameters, and the stochastic model also undergoes a similar dynamical phenomenon for which we call stochastic Hopf bifurcation without parameters. We also numerically confirm such stochastic dynamical property.

This is a joint work with Tuan Anh Phan.

Strong solutions of stochastic differential equations with square integrable drift

Rongrong TIAN

College of Science, Wuhan University of Technology, China

In this talk, we prove the unique strong solvability of time inhomogeneous stochastic differential equations with square integrable (in time) drift coefficients. Moreover, we prove that the unique strong solution has a continuous modification, which is β-Hölder continuous in space variable for every $\beta \in (0, 1)$, and as an $L^2(\Omega \times (0, T))$ valued function, it is differentiable as well.

Joint work with Jinlong Wei.

On recurrence properties of 1-dimensional discrete oscillating random walk

Tran Duy VO

Faculté des Sciences et Techniques, Institut Denis Poisson, Université de Tours, France

In parallel with many studies of classical stochastic processes, oscillating random walks (ORW), which were introduced systematically by Kemperman, have been found as good models with several applications. In this talk, I will focus on the discrete ORW in dimension 1: that is how its orbit changes over time, and by studying the behavior of its corresponding sub-process in which only states at crossing times are considered, the recurrence of the general process is deduced under some Holder type moment assumptions.

An Optimal Control Method to Compute the Most Likely Transition Path for Stochastic Dynamical Systems with Jumps

Wei WEI

Center for Mathematical Science, Huazhong University of Science & Technology, China

Many complex real world phenomena exhibit abrupt, intermittent or jumping behaviors, which are more suitable to be described by stochastic differential equations under non-Gaussian Lévy noise. Among these complex phenomena, the most likely transition paths between metastable states are important since these rare events may have high impact in certain scenarios. Based on the large deviation principle, the most likely transition path could be treated as the minimizer of the rate function upon paths that connect two points. One of the challenges to calculate the most likely transition path for stochastic dynamical systems under non-Gaussian Lévy noise is that the associated rate function can not be explicitly expressed by paths. For this reason, we formulate an optimal control problem to obtain the optimal state as the most likely transition path. We then develop a neural network method to solve this issue. Several experiments are investigated for both Gaussian and non-Gaussian cases.

Characterising the path-independence of stochastic differential equations: a problem arising in financial modelling

Jiang-Lun WU

Department of Mathematics Computational Foundry, Swansea University, UK

This talk will address a problem arising in financial modelling with stochastic differential equations (SDEs). A characterisation theorem will be derived in which we establish a new link from SDEs to nonlinear parabolic PDEs. Starting from the necessary and sufficient conditions of the path-independence of the density of Girsanov transform for SDEs, we are able to derive a characterisation by means of nonlinear parabolic equations of Burgers-KPZ type. Extensions to the cases of degenerated SDEs, jump SDEs, DDSDEs, as well as to (infinite dimensional) SDEs on separable Hilbert spaces will be discussed. A perspective to stochastically deformed dynamical systems will be briefly considered.

Transitions between weak-noise-induced resonances in a multiple timescale neural system

Marius YAMAKOU

Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

Using a stochastic slow-fast dynamical system derived from a computational neuroscience model, we will uncover, independently, the mechanisms that underlie two forms of weak-noise-induced resonance mechanisms, namely, self-induced stochastic resonance (SISR) and inverse stochastic resonance (ISR). Then, we will show that SISR and ISR are related through the relative geometric positioning (and stability) of the fixed point and the generic folded singularity of the system's critical manifold. This result could explain the experimental observation that real biological neurons with similar physiological features and stochastic synaptic inputs sometimes encode quite different information.

Stochastic bifurcation for two-time-scale dynamical system with α-stable Levy noise

Shenglan YUAN

Institut für Mathematik, Universität Augsburg, Germany

This work focuses on stochastic bifurcation for a slow–fast dynamical system driven by non-Gaussian α-stable Lévy noise. We prove the main result for the stochastic equilibrium states for the original system and the reduced system based on the random slow manifold. Then, it is verified that the slow reduced system bears the stochastic bifurcation phenomenon inherited from the original system. Furthermore, we investigate the number and stability type of stochastic equilibrium states for dynamical systems through numerical simulations, and it is illustrated that the slow reduced system captures the stochastic bifurcation of the original system.

This is a joint work with Zhigang Zeng and Jinqiao Duan.

Random attractors for rough stochastic partial differential equations

Caibin ZENG

School of Mathematics, South China University of Technology, China

In this talk, we will report the existence of random attractors for rough partial dif ferential equations driven by nonlinear multiplicative Hölder rough paths with exponents in (1/3, 1/2]. Our approach relies upon rough paths theory and stop ping time analysis in a suitable scale of interpolation spaces. The core step is to derive the adequate algebraic and analytical properties of the stopping time sequence, which allows us to establish the required compact tempered ab sorbing set. The existence of a pullback attractor for the generated random dynamical system is straightforward. An illustrative example is presented by reaction-diffusion equations subjected to fractional Brownian rough paths.

This is a joint work with Qigui Yang and Xiaofan Lin.

Effective wave factorization for a stochastic Schrödinger equation

Ao ZHANG

School of Mathematics and Statistics, Huazhong University of Science and Technology, China

We study the homogenization of a stochastic Schrödinger equation with a large periodic potential in solid state physics. Denoting by ε the period, the potential is scaled as ε^{-2}. Under a generic assumption on the spectral properties of the associated cell problem, we prove that the solution can be approximately factorized as the product of a fast oscillating cell eigenfunction and of a slowly varying solution of an effective equation. Our method is based on two-scale convergence and Bloch waves theory.