西北工業大學
NORTHWESTERN POLYTECHNICAL UNIVERSITY

国家天元数学西北中心
TIANYUAN MATHEMATICAL CENTER IN NORTHWEST CHINA

Workshop Program

for

IWDNS-2019

The International Workshop on

Dynamics, Nonlinearity and Stochasticity

Xi'an, China
1-4 April, 2019

Workshop Introduction

IWDNS-2019, the workshop of **Dynamics**, **Nonlinearity and Stochasticity**, will be held at **Northwestern Polytechnical University, Xi'an, China, on April 1-4, 2019**. This workshop aims to provide a forum for researchers and practitioners to present, discuss and disseminate recent advances in nonlinearity, dynamics and stochasticity research. **All speakers are invited and each talk will spend 50 mins including Q&A.** The themes of this workshop include, but are not limited to: complex networks, big data, stochastic control, neurodynamic, nonlinear dynamics and control, biology, physics, mechanics, mathematics, life sciences, statistics, etc. Participants from universities, research institutes and industrial companies are welcome.

Workshop Organizations

•Sponsors:

Tianyuan Mathematical Center in Northwest China
Northwestern Polytechnical University, Xi'an, China
Beifang University of Nationalities, Yinchuan, China
National Natural Science Foundation of China

•Organizers:

Prof. Yong Xu (Northwestern Polytechnical University, China)
Prof. Ralf Metzler (University of Potsdam, Germany)
Prof. Jürgen Kurths (Potsdam Institute for Climate Impact Research / Humboldt University, Germany)

Program Overview

Date	Time	Contents
April 1, 2019 (Monday)	08:00-08:30	Opening Ceremony
	08:30-10:10	Keynote Lectures
	10:10-10:30	Coffee Break
	10:30-12:10	Keynote Lectures
	12:10-13:40	Lunch
	13:40-16:10	Keynote Lectures
	16:10-20:00	Discussion
April 2, 2019 (Tuesday)	08:10-09:50	Keynote Lectures
	09:50-10:30	Coffee Break/Poster
	10:30-12:10	Keynote Lectures
	12:10-13:40	Lunch
	13:40-15:20	Keynote Lectures
	15:20-16:10	Poster Presentation
	16:10-16:30	Coffee Break
	16:30-18:10	Keynote Lectures
	18:10-20:30	Banquet
April 3, 2019 (Wednesday)	08:10-09:50	Keynote Lectures
	09:50-10:30	Coffee Break/Poster
	10:30-12:10	Keynote Lectures
	12:10-14:00	Lunch
	14:00-19:00	Discussion
	19:00-20:30	Dinner
April 4, 2019 (Thursday)	08:10-09:50	Keynote Lectures
	09:50-10:30	Coffee Break/Poster
	10:30-12:10	Keynote Lectures
	12:10-13:40	Lunch
	13:40-15:20	Keynote Lectures
	15:20-15:40	Coffee Break
	15:40-17:20	Keynote Lectures
	17:20-18:00	Discussion
	18:00-20:00	Dinner

Workshop Schedule

Date: April 1, 2019	**Location: The multi-function hall (2nd Floor)**	
08:00-08:30	**Opening Ceremony** **(Welcome Speech/ Group Photo)**	
08:30-09:20	**Weiqiu Zhu:** Nonlinear stochastic dynamics and control of quasi-Hamiltonian systems	Chair: **Jürgen Kurths**
09:20-10:10	**Tomasz Kapitaniak:** Traveling chimera states for coupled pendula	
10:10-10:30	**Coffee Break**	
10:30-11:20	**Syamal K. Dana:** Sudden transition to large amplitude oscillation: routes to extreme events	Chair: **Jun Jiang**
11:20-12:10	**Celso Grebogi:** Predicting and controlling tipping points in networked systems	
12:10-13:40	**Lunch (1st Floor)**	
13:40-14:30	**Haipeng Ren:** Why and how the chaos properties can be used to improve the wireless communication performance?	Chair: **Ralf Metzler**
14:30-15:20	**Flavio Seno:** Brownian yet non-Gaussian diffusion in heterogeneous media	
15:20-16:10	**Bjoern Schmalfuss:** Synchronization of stochastic lattice (and/or spd) equations	
16:10-20:00	**Discussion**	

Date: April 2, 2019	**Location: The multi-function hall (2nd Floor)**	
08:10-09:00	**Yangquan Chen:** Optimal stochasticity entails fractional calculus that enlightens big data and machine learning research	Chair: **Xiaofan Li**
09:00-09:50	**Frank Hellmann:** Powergrid questions for oscillator networks: Stochastic spreading in networked systems and nonlinear stability	
09:50-10:30	**Coffee Break/Poster**	
10:30-11:20	**Jianbing Chen:** PDEM-based uncertainty quantification and stochastic dynamic response of nonlinear systems	Chair: **Xianbin Liu**
11:20-12:10	**Sudeshna Sinha:** Chaotic attractor hopping yields logic operations	
12:10-13:40	**Lunch (1st Floor)**	
13:40-14:30	**Liang Huang:** Relativistic quantum chaos	Chair: **Yangquan Chen**
14:30-15:20	**Fengyu Wang:** Coupling and applications	
15:20-16:10	**Poster Presentation (3 mins/each)**	
16:10-16:30	**Coffee Break**	
16:30-17:20	**Yang Tang:** Coordination control for hybrid nonlinear multi-agent systems	Chair: **Bjoern Schmalfuss**
15:20-18:10	**Ralf Metzler:** Anomalous diffusion in membranes	
18:10-20:30	**Banquet (2nd Floor)**	

Date: April 3, 2019	**Location: The multi-function hall (2nd Floor)**	
08:10-09:00	**Xiaofan Li:** Numerical simulations of macroscopic quantities for stochastic differential equations with α-stable processes	Chair: **Yuzuru Inahama**
09:00-09:50	**Wei Lin:** Control of complex networks: feedbacks, time delays, and randomness	
09:50-10:30	**Coffee Break/Poster**	
10:30-11:20	**Alexey Zaikin:** The Brain as a complex network of networks: where is intelligence and consciousness?	Chair: **Wei Lin**
11:20-12:10	**Gianni Pagnini:** Centre-of-mass like superposition of Ornstein-Uhlenbeck process: a pathway to non-autonomous stochastic differential equations and to fractional diffusion	
12:10-14:00	**Lunch (1st Floor)**	
14:00-19:00	**Discussion**	
19:00-20:30	**Dinner (1st Floor)**	

Date: April 4, 2019	Location: The multi-function hall (2nd Floor)	
08:10-09:00	**Guanrong Chen:** Further on equilibria and attractors of 3D chaotic systems	Chair: **Sudeshna Sinha**
09:00-09:50	**Jae-Hyung Jeon:** Lateral anomalous diffusion in lipid bilayers: stochasticity, molecular crowding, and the breakdown of the Saffman-Delbrück theory	
09:50-10:30	**Coffee Break/Poster**	
10:30-11:20	**Yuzuru Inahama:** Stochastic complex Ginzburg-Landau equation with space-time white noise	Chair: **Guanrong Chen**
11:20-12:10	**Xianbin Liu:** On the dynamical behaviors of several nonlinear stochastic systems based on the large derivation theory	
12:10-13:40	**Lunch (1st Floor)**	
13:40-14:30	**Ulrike Feudel:** Extreme events in delay-coupled FitzHugh-Nagumo oscillators	Chair: **Alexey Zaikin**
14:30-15:20	**Gamal Mahmoud:** Complex modified projective synchronization of two chaotic complex nonlinear systems	
15:20-15:40	**Coffee Break**	
15:40-16:30	**Jun Jiang:** Enhance capability and efficiency of cell mapping method through parallel computing and evolving probabilistic vector	Chair: **Tomasz Kapitaniak**
16:30-17:20	**Jürgen Kurths:** Complex network approach reveals global pattern of extreme-rainfall teleconnection	
17:20-18:00	**Discussion**	
18:00-20:00	**Dinner (1st Floor)**	

Topics and Abstracts

Topic: **Nonlinear stochastic dynamics and control of quasi-Hamiltonian systems**

Speaker: **Weiqiu Zhu** (Zhejiang University, China)

Abstract: The significant advances in nonlinear stochastic dynamics and control in Hamiltonian formulation during the past decades are summarized. The exact stationary solutions and equivalent nonlinear system method of Gaussian white noises excited and dissipated Hamiltonian systems, the stochastic averaging method for quasi Hamiltonian systems, the stochastic stability, stochastic bifurcation, first-passage time and nonlinear stochastic optimal control of quasi Hamiltonian systems are included. Possible extension and applications of the theory are also pointed out.

Topic: **Traveling chimera states for coupled pendula**

Speaker: **Tomasz Kapitaniak** (Technical University of Lodz, Poland)

Abstract: We investigate the phenomenon of traveling chimera states in the ring of self-excited coupled pendula suspended on the horizontally oscillating wheel. The bifurcation scenario of chimera creation and destruction is discussed, and the influence of the suspension's parameters on possible behavior is studied. We describe the properties of the investigated states, analyzing the traveling time as well as the dynamics of the pendula, depending on their position within different pattern's regions. The energy transfer method has been used to present how the units cooperate with each other, making the chimera arising possible. Unlike other studies on traveling chimera states, we examine the typical mechanical system including simple topology of coupling, which suggests that the described behavior can be observed snaturally in the models of coupled dynamical oscillators.

Topic: **Sudden transition to large amplitude oscillation: routes to extreme events**

Speaker: **Syamal K. Dana** (Jadavpur University, India)

Abstract: Extreme events create devastation to life and economy. Understanding the origin of extreme events is extremely important for mitigating disaster with an early prediction. Attempts have been made to understand the origin of extreme events using simple dynamical systems first and then to search for a technique to predict, which is

a very difficult task. In this talk, I present three major dynamical processes of sudden transitions to large amplitude oscillations via crisis-induced intermittency, Pomeau-Manneville intermittency and breakdown of quasiperiodic motion. We present our observations in two example systems, a forced Liénard system and a coupled neuron model that show evidence of above three general routes to sudden amplitude explosion leading to extreme events.

References:

[1] A. Mishra, S.Saha, M. Vigneshwaran, Pinaki Pal, T. Kapitaniak, and S. K. Dana, Phys. Rev. E 97, 062311 (2018).

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Topic: **Predicting and controlling tipping points in networked systems**

Speaker: **Celso Grebogi** (University of Aberdeen, UK)

Abstract: A variety of complex dynamical systems, ranging from ecosystems and the climate to economic, social, and infrastructure systems, can exhibit a tipping point at which an abrupt transition to a catastrophic state occurs. To understand the dynamical properties of the system near a tipping point, to predict the tendency for the system to drift toward it, to issue early warnings, and finally to apply control to reverse or slow down the trend, are outstanding and extremely challenging problems. We consider empirical mutualistic networks of pollinators and plants from the real world and investigate the issues of control, recovery, and early warning indicators. In particular, when considering bipartite networks, both exhibit a tipping point as a parameter characterising the population decay changes continuously, at which the system collapses suddenly to zero abundance for all the species. We articulate two control strategies: (a) maintaining the abundance of a single influential pollinator and (b) eliminating the factors contributing to the decay of the pollinator. In both cases, we find that control can turn the sudden collapse into a more gradual process in the sense that extinction of the species occurs sequentially with variation of the parameter, indicating that control can effectively delay the occurrence of global extinction. We then investigate population revival as the bifurcation parameter varies in the opposite direction away from the tipping point. Without control, there is a hysteresis loop which indicates that, in order to revive the species abundance to the original level, the parameter needs to be further away from the tipping point, i.e., the environment needs

to be fitter than before the collapse. However, with control the hysteresis behaviour diminishes, suggesting the positive role of control in facilitating species revival. To develop effective control strategies to prevent the system from drifting towards a tipping point is an unsolved problem at the present, and we hope our work can shed light on the challenging and significant problem of understanding and controlling tipping point dynamics in nonlinear and complex systems.

Topic: **Why and how the chaos properties can be used to improve the wireless communication performance?**

Speaker: **Haipeng Ren** (Xi'an Technological university, China)

Abstract: In this talk, we will explain how the wireless channel modify the chaotic signal transmitted through it, and give some invariant property of chaos. From this fact, we further explain the return map modification of chaotic dynamics after multipath propagation, and its effect on the decoding for information transmission leading to the higher bit error rate. Then a theoretical remedy to the problem is proposed to eliminate effect of the multipath propagation. A finite impulse response filter structure, also referred as to shape forming filter in communication system, is used to form the baseband chaotic signal for wireless communication, then the corresponding matched filter is used to maximize the signal to noise ratio, before decoding the symbol, the practical remedy, i.e., sub-optimal threshold, is then proposed considering the theoretical one being impossible. The experimental platform and configuration are introduced to verify the analysis results. Comparison to nowaday commonly used traditional wireless communication method shows the better performance and easy implementation of the method using chaos property. Further work using Artifical Intelligence (AI) to improve the accuraccy of the threshold is also given to further improve the performance.

Topic: **Brownian yet non-Gaussian diffusion in heterogeneous media**

Speaker: **Flavio Seno** (University of Padova, Italy)

Abstract: TBD

Topic: **Synchronization of stochastic lattice (and/or spd) equations**

Speaker: **Bjoern Schmalfuss** (Friedrich-Schiller-Universität Jena, Germany)

Abstract: Human brain has a very specific design as a result of a long evolution: a network of neurons linked in a very complex way is overlapped with a network of coupled astrocytes which are also linked to neurons. Naturally the research question arises how this design is related to the main feature of human brain, namely, ability to maintain a certain level of consciousness and awareness. To answer the question how quantify level of consciousness, recently the Integrated Information Theory of Consciousness has been developed, controversially claimed not only as a way to measure the complexity of brain but also its level of consciousness. Here I will report our results on a simple but realistic model of neuro-glial network and show that presence of astrocyte could contribute to the generation of positive Integrated Information and, hence, its evolutionary appearance was important to develop consciousness.

Topic: **Optimal stochasticity entails fractional calculus that enlightens big data and machine learning research**

Speaker: **Yangquan Chen** (University of California, USA)

Abstract: This talk tries to connect stochasticity and fractional calculus in a generic sense. It has been widely experienced that randomness, when properly introduced, could enhance performance in optimization process, modeling and control etc. When asking what is the "optimal" randomness, in many cases, heavy-tailness (HT, or algebraic tail) emerges. A widely known example is the Levy flights used in population-based random search (e.g. Cuckoo search). Fractional calculus is shown to play an important role in characterizing HT processes. Thus the fractional order can be regarded as a tuning knob to achieve "optimal stochasticity". In turn, we can say "optimal stochasticity" entails fractional calculus. In machine learning problems, optimal stochasticity may lead us to better than the best optimization performance. An illustrative example is given. For big data research, how to best quantify the variability leads us to the so-called "fractional-order data analytics (FODA)" using fractional calculus based methods. In summary, this talk attempts to convince the audience that whenever there is randomness, there is a chance to ask what is the optimal randomness, and in turn a chance to use fractional calculus.

Topic: **Powergrid questions for oscillator networks: Stochastic spreading in networked systems and nonlinear stability**

Speaker: **Frank Hellmann** (Potsdam Institute for Climate Impact Research, Germany)

Abstract: Powergrids are continental sized machines of coupled oscillators. While they traditionally consisted of relatively few machines that fed a distribution network, the ongoing energy transition and the shift to distributed renewable generation will see the system change to one in which a large number of oscillators interact dynamically. The task to keep the system stable thus raises important questions for the study of network dynamics.

In this talk I will review recent results on the linear and non-linear network behavior of inertial oscillators. Such oscillators provide an interesting model for the dynamics of current and future power grids and their control. In both cases we see that the presence of many subtle dynamical effects in the behavior of the oscillators and the lines, such as energy losses in the network and small delays in the control action, can have large emergent effects on the characteristics of the entire network.

Topic: **PDEM-based uncertainty quantification and stochastic dynamic response of nonlinear systems**

Speaker: **Jianbing Chen** (Tongji University, China)

Abstract: Uncertainty are widely encountered in engineering fields, in particular in civil engineering. Actually, stochastic excitations, such as earthquake ground motions and strong wind speeds, are stochastic processes. The mechanical parameters, such as modulus of elasticity and strength, are also random in nature, and should be regarded as random variables or even random fields. Therefore, to quantify the uncertainties in nonlinear structures, and to capture the propagation of uncertainties are of great importance for engineering practice. Generally, great challenges exist due to: (1) large degrees of freedom of the system; (2) strong nonlinearity in the mechanical behaviors, which even can not be expressed in analytical form; and (3) non-Gaussian distributions of the random variables or random fields.

In the present paper a PDEM-based methodology is outlined. Firstly, the theoretical basis of the probability density evolution method (PDEM) is delineated. Both state space description and random event description of the principle of preservation are discussed, and the generalized density evolution equation, which is a state-variable

decoupled one- or any arbitrary-dimensional partial differential equation governing the evolution of marginal or joint probability density function, is derived [1]. Error estimate of the numerical algorithm for solution of PDEM based on the extensions of Koksma-Hlawka inequality in terms of EF-discrepancy and GF-discrepancy is developed [2,3]. Further, an ensemble-evolution equation is further given. On the basis of PDEM, a compatible probabilistic framework for the quantification of both epistemic and aleatory uncertainty by synthesizing the PDEM and the change of probability measure (COM) is introduced. Highly efficient method is then developed for practical engineering applications when epistemic uncertainties are also involved in the distribution of basic random parameters, which makes it possible to online predict the performance or reliability of engineering systems based on real-time information updating in the context of Big-Data.

References:

[1] Li J, Chen JB. Stochastic Dynamics of Structures. John Wiley & Sons, 2009.

[2] Chen JB, Chan JP. Error estimate of point selection in uncertainty quantification of nonlinear structures involving multiple nonuniformly distributed parameters. Int J Numer Methods Eng. 2019; 1-25. https://doi.org/10.1002/nme.6025

[3] Chen JB, Wan ZQ. A compatible probabilistic framework for quantification of simultaneous aleatory and epistemic uncertainty of basic parameters of structures by synthesizing the change of measure and change of random variables. Structural Safety, 2019, 78: 76-87.

[4] Chen JB, Rui ZM. Dimension-reduced FPK equation for additive white-noise excited nonlinear structures. Probabilistic Engineering Mechanics 2018, 53: 1-13.

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Topic: **Chaotic attractor hopping yields logic operations**

Speaker: **Sudeshna Sinha** (Indian Institute of Science Education and Research, India)

Abstract: Certain nonlinear systems can switch between dynamical attractors occupying different regions of phase space, under variation of parameters or initial states. In this work we exploit this feature to obtain reliable logic operations. With logic output 0/1 mapped to dynamical attractors bounded in distinct regions of phase space, and logic inputs encoded by a very small bias parameter, we explicitly

demonstrate that the system hops consistently in response to an external input stream, operating effectively as a reliable logic gate. This system offers the advantage that very low-amplitude inputs yield highly amplified outputs. Additionally, different dynamical variables in the system yield complementary logic operations in parallel. Further, we show that in certain parameter regions noise aids the reliability of logic operations, and is actually necessary for obtaining consistent outputs. This leads us to a generalization of the concept of Logical Stochastic Resonance to attractors more complex than fixed point states, such as periodic or chaotic attractors. Lastly, the results are verified in electronic circuit experiments, demonstrating the robustness of the phenomena.

Topic: Relativistic quantum chaos

Speaker: **Liang Huang** (Lanzhou University, China)

Abstract: Classical-quantum correspondence has been an intriguing issue ever since the propose of quantum theory. The searching for signatures of classically nonintegrable dynamics in quantum systems comprises the rich interdisciplinary studies of quantum chaos. In this talk, we will present our recent efforts extending the understanding of these phenomena into relativistic quantum systems. Comparison with those of the Schroedinger electrons will also be present to contrast the uncommon phenomena in relativistic quantum systems.

Topic: **Coupling and applications**

Speaker: **Fengyu Wang** (Tianjin University, Tianjin, China)

Abstract: Satarting from a simple example of transportation problem, we introduce coupling for probability distributions and Markov processes, and apply the coupling method to establish Liouville theorem, gradient estimates, spectral gap estimates, and Harnack inequalities.

Topic: **Coordination control for hybrid nonlinear multi-agent systems**

Speaker: **Yang Tang** (East China University of Science and Technology, China)

Abstract: Networked multi-agent systems, usually composed of a number of homogeneous/heterogeneous agents interconnected via communication channels, have shown their wide applicability in various areas, such as power grids, lasers, bioinformatics, sensor networks, vehicles, robotics and neuroscience, for instance. In this talk, coordination of complex multi-agent systems will be presented. Here, we consider hybrid multi-agent networks: consensus with directed time-varying topology and sampled data consensus. We have also performed some experiments to verify the effectiveness of the obtained results. Then, finally, conclusions will be drawn.

Topic: **Anomalous diffusion in membranes**

Speaker: **Ralf Metzler** (University of Potsdam, Germany)

Abstract: I will present results from Molecular Dynamics simulations of pure and crowded lipid bilayer systems, giving evidence of anomalous diffusion. While in the pure lipid bilayer this anomaly is very short ranged, the addition of colesterols or the passage to the gel phase leads to extended anomalous diffusion. The character of the dynamics corresponds to that of the fractional Brownian motion in the dilute bilayer, changing to non-Gaussian motion when the bilayer is crowded with proteins. Real biological membranes show macroscopic anomalous diffusion, which is evidenced from superresolution microscopy experiments. In particular the motion becomes non-ergodic and ageing.

Topic: **Numerical simulations of macroscopic quantities for stochastic differential equations with α-stable processes**

Speaker: **Xiaofan Li** (Illinois Institute of Technology, USA)

Abstract: The mean first exit time, escape probability and transitional probability density are utilized to quantify dynamical behaviors of stochastic differential equations with non-Gaussian, α-stable type Lévy motions. Taking advantage of the Toeplitz matrix structure of the time-space discretization, a fast and accurate numerical algorithm is proposed to simulate the nonlocal Fokker-Planck equations on either a bounded or infinite domain. Under a specified condition, the scheme is shown to satisfy a discrete maximum principle and to be convergent. The numerical results for two prototypical stochastic systems, the Ornstein-Uhlenbeck system and the double-well system are shown.

Topic: **Control of complex networks: feedbacks, time delays, and randomness**

Speaker: **Wei Lin** (Fudan University, China)

Abstract: In this talk, we will introduce the recent progress on the control of complex networks when feedbacks, time delays, and randomness are, respectively, taken into account in the study. In particular, when these factors are imported into the control protocols, some advantages such as reduction of time and energy costs can emerge. We will use some representative examples to illustrate the analytical findings and show their potential usefulness in real-world systems.

Topic: **The Brain as a complex network of networks: where is intelligence and consciousness?**

Speaker: **Alexey Zaikin** (University College London, UK)

Abstract: Human brain has a very specific design as a result of a long evolution: a network of neurons linked in a very complex way is overlapped with a network of coupled astrocytes which are also linked to neurons. Naturally the research question arises how this design is related to the main feature of human brain, namely, ability to maintain a certain level of consciousness and awareness. To answer the question how quantify level of consciousness, recently the Integrated Information Theory of Consciousness has been developed, controversially claimed not only as a way to measure the complexity of brain but also its level of consciousness. Here I will report our results on a simple but realistic model of neuro-glial network and show that presence of astrocyte could contribute to the generation of positive Integrated Information and, hence, its evolutionary appearance was important to develop consciousness.

Topic: **Centre-of-mass like superposition of Ornstein-Uhlenbeck process: a pathway to non-autonomous stochastic differential equations and to fractional diffusion**

Speaker: **Gianni Pagnini** (Basque Center for Applied Mathematics, Spain)

Abstract: A heterogeneous ensemble of Ornstein-Uhlenbeck processes featuring a population of relaxation times and a population of noise amplitudes is considered. The centre-of-mass like variable corresponding to this ensemble results to be statistically equivalent to a process driven by a non-autonomous stochastic differential equation

with time-dependent drift and a white noise, and equivalent in distribution to a randomly-scaled Gaussian process, i.e., a process built by the product of a Gaussian process times a non-negative independent random variable [1]. This last result establishes a connection with the so-called generalized grey Brownian motion [2]. The link between the Ornstein-Uhlenbeck process and the Langevin equation provides a dynamical framework that allows for discussing this approach under physical perspectives in view, for example, of applications for studying anomalous diffusion in biological systems [3, 4].

References:

[1] D'Ovidio, M., Vitali, S., Sposini, V., Sliusarenko, O., Paradisi, P., Castellani, G., Pagnini, G., Centre-of-mass like superposition of Ornstein-Uhlenbeck processes: A pathway to non-autonomous stochastic differential equations and to fractional diffusion. Fract. Calc. Appl. Anal., 21, 2018, 1420-1435.

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[3] Vitali, S., Sposini, V., Sliusarenko, O., Paradisi, P., Castellani, G., Pagnini, G., Langevin equation in complex media and anomalous diffusion. J. R. Soc. Interface, 15, 2018, 20180282.

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Topic: **Further on equilibria and attractors of 3D chaotic systems**

Speaker: **Guanrong Chen** (City University of Hong Kong, Hong Kong, China)

Abstract: In a typical 3D autonomous chaotic system, such as the Lorenz or the Rossler system, the number of equilibria is three or two. Today, we are able to find or construct a relatively simple 3D autonomous chaotic system that can have any desired number of equilibria, including simple systems without equilibrium or with infinitely many. Furthermore, we are able to find or construct a relatively simple 3D autonomous or non-autonomous system that can have infinitely many chaotic attractors. This talk will introduce the main ideas and methodologies. Since these are non-hyperbolic systems, their theoretical analyses pose great challenges for future research studies.

Topic: **Lateral anomalous diffusion in lipid bilayers: stochasticity, molecular crowding, and the breakdown of the Saffman-Delbrück theory**

Speaker: **Jae-Hyung Jeon** (Pohang University of Science and Technology, Korea)

Abstract: Lipid bilayers are quasi two-dimensional, crowded systems composed of various phospholipid molecules and membrane proteins [1]. It is known that the lipids and proteins carry out thermally driven lateral diffusion and thus constantly reorganize the membrane. Using the molecular dynamics simulations, theoretical modeling of anomalous diffusion, and the single-molecule experiments, we quantify the stochastic properties of the lateral diffusion in membranes at varying circumstances. We show that the lateral diffusion attains more anomalous characters as the membrane complexity is increased by adding cholesterol molecules and/or proteins. In the absence of membrane proteins the anomalous motion is universally described by the gaussian anomalous diffusive process called fractional Brownian motion (FBM) regardless of molecular details of the lipid structure and lipid phases [2]. However, it is found that this FBM picture is no longer valid if the membrane is crowded with proteins [3]. We present how the crowding of membrane proteins changes statistical complexities of the anomalous diffusion in membranes. Finally, we investigate the case that the lateral diffusion of proteins is hindered by antibodies attached to extracellular domain of them outside the membrane [4]. We show by the experiment that the diffusivity of the proteins is significantly reduced beyond the Saffman-Delbrück theory by the effects of attachment of antibodies and their crowding. We explain the observed diffusion dynamics in terms of two-body collisions and their excess entropy, and also provide numerical evidence from the corresponding coarse-grained simulation.

References:

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[2] J.-H. Jeon, H. M.-S. Monne, M. Javanainen, & R. Metzler, Phys Rev Lett 109, 188103 (2012).

[3] J.-H. Jeon, M. Javanainen, H. Martinez-Seara, R. Metzler, and I. Vattulainen, Phys Rev X 6, 021006 (2016).

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Topic: **Stochastic complex Ginzburg-Landau equation with space-time white noise**

Speaker: **Yuzuru Inahama** (Kyushu University, Japan)

Abstract: We discuss the stochastic cubic complex Ginzburg-Landau equation with complex-valued space-time white noise on the three dimensional torus. This nonlinear equation is so singular that it can only be understood in a renormalized sense. In this talk we prove local well-posedness of this equation in the framework of Gubinelli-Imkeller-Perkowski's paracontrolled calculus, which is based on Bony's para-differential calculus. (This is a joint work with Masato Hoshino and Nobuaki Naganuma).

Topic: **On the dynamical behaviors of several nonlinear stochastic systems based on the large derivation theory**

Speaker: **Xianbin Liu** (Nanjing University of Aeronautics and Astronautics, Nanjing, China)

Abstract: Due to the pervasiveness of random perturbations in nature, stochastic dynamical behaviors of nonlinear systems have consistently been one of the research focuses and challenges in areas of both natural and engineering sciences. The main reason for this difficulty is that over a sufficiently long time scale, the randomness in perturbations could lead to large dervations between the stochastic dynamical responses of the system and the deterministic ones. This work aims at investigating the phenomena of large deviations occurring distinctively in random dynamical systems, facilitating to reveal the interactions between randomness and nonlinearity ubiquitous in the physical world and the engendered complexities. The main results and findings are briefly concluded as follows:

1) **Escape mechanism from a non-hyperbolic chaotic attractor.** Within the non-hyperbolic chaotic attractor exists a complicated structure of homoclinic tangencies. The attractor deformation caused by noise is the most obvious at the primary homoclinic tangency (PHT). Nearby the attractor lie several saddle-type periodic orbits, of which the invariant manifolds are mutualy embedded and finally constitute a hierarchical heteroclinic crossings of stable and unstable manifolds. Selecting the PHT as the initial point of the entire escape process, we calculated the global minimum of the action function and its corresponding optimal path, which shows an excellent agreement with the most probable escape

path in statistical sense. Through analyzing the noise-induced fluctuational force and the momentum of the ancillary Hamilton system step by step, it was found that accompanied by each remarkable fluctuation of the momentum, the optimal path jumped from the lower level of invariant manifold to the upper one. Moreover, the entire escape is fulfilled by the stepwise jumps along the hierarchical heteroclinic crossings of manifolds. In the limit of weak noise, it is this deterministic structure of the manifolds that determines the mechanism of fluctuational escape from the non-hyperbolic chaotic attractor. In addition, we also discussed the underlying reason of the sophisticated structure of the action plot and the associated escape paths of various modes.

2) **Crossing the quasi-threshold manifold in an extended eacaping problem.** By selecting the quasi-threshold manifold given by a specific canard trajectory as the boundary and computing the distribution of quasi-potential along this boundary, we found a minimum value of quasi-potential along the quasi-threshold. This minimum point plays the role of a saddle in classic escaping problems. That is, the optimal path manifests itself as approaching the quasi-threshold manifold tangentially and crossing it right through the minimum point and whereafter fire a typical spike via following deterministic orbits. Besides, under the excitation of finite noise statistical crossing samples display the single-sided distribution which arises in classic saddle avoidance as well. We elaborated the cause of the statistics by analyzing the quasi-potential and deterministic dynamics. The effect of different noise ratios on extended escaping problems is also studied, and we found that the internal thermal noise characterizing the states of ion channels dominated the neural spikings. The more frequently the ions exchange between both sides of channels, the more easily an action potential produces.

3) **Calculations of singularities in the topological structure of Lagrangian manifolds.** Through studying the behaviors of solutions to the Hamilton-Jacobi equation, transport equation and Riccati equation, we discussed the mathematical implications and geometrical meanings of the singulairities occurring the Lagrangian manifold. Based on that, we also proposed individual computing method to each singularity. To be specific, the switching line is the projection of the non-differential set in the viscosity solution to the Hamilton-Jacobi equation. It follows that the location of the switching line can be determined via calculating all discontinuity in the first–order partial derivatives of quasi-potential. In

addition, caustics can be found by the divergence of solutions to the transport equation and Riccati equation, since the second-order derivatives of the quasi-potential describe the slope of tangent space of the Lagrangian manifold. The above methods were applied to two dynamical systems to verify the reliability of the above methods. In particular, we investigated the singular bifurcations by varying the parameters in Maier-Stein system.

4) **Modification to the action function of zero noise limit.** In order to compute the optimal path and exit location in finite noise intensity, we proposed a modification to the action function of zero noise limit by introducing the noise intensity of the first order. We found it to be an evidence for statistical results in finite noise intensity.
5) **Mechanical significance of the non-differentiable set in the quasi-potential.** By studying the escape problem of the stochatisc Morris-Lecar model of Type-I and Type-II excitability, we found that the existence of the switching line could bring the optimal paths into non-smooth dynamics. To be precice, when an optimal encounters the swiching line, it cannot cross it but changes its direction abruptly and moves along the switching line. This discontinuity comes from, in essence, the velocity field which the optimal paths follows is a non-smooth dynamical system. Thus the physical concept of the switching line is in fact corresponding to the sliding set in mechanical and dynamcal system framework. Besides, under the condition of Type-II excitability, we discussed and compared two different choices of exit boundary in details. We could draw a conclusion that from the viewpoint of both dynamics and energy, it is more reasonable to choose the quasi-threshold manifold given by the canard trajectories as the exit boundary.

Keyword: large derivation theory, optimal paths, quasi-potential, action functional, singularities, strange attractor, neuronal models.

Topic: **Extreme events in delay-coupled FitzHugh-Nagumo oscillators**

Speaker: **Ulrike Feudel** (Carl von Ossietzky University Oldenburg, Germany)

Abstract: The study of extreme events has gained increasing attention in recent years due to its ubiquitous appearance in a wide variety of important physical situations ranging from natural disasters to financial crises. Previous studies have indicated many factors and mechanisms which may cause such rare, recurrent, aperiodic events which have a large impact on dynamical systems. Some of these include progressive

spatial synchronization and an interior crisis in networks of non-identical relaxation oscillators.

An important factor which often shapes the dynamics of systems in which such extreme events are observed is time delayed coupling. For instance, neural activities across different regions of the brain – whose synchrony may lead to epileptic seizures – are coupled by time delayed coupling. Moreover, as the flow of information in these networks might take different routes to travel from the source to the destination, more than one delay could be associated with a single pair of nodes. The impact of these time-delayed couplings on the emergence of extreme events has not yet been analyzed. In this talk, we investigate if delay couplings alone can induce extreme events in excitable systems.

To study the impact of such delay-couplings, we investigate a system of two identical FitzHugh-Nagumo oscillators diffusively coupled by single or multiple delays. We show that such a system shows rich dynamics which comprises of in-phase and out of-phase extreme events. The stability of the synchronization manifold and its invariant subsets plays a crucial role in determining the qualitative nature of the dynamics. We also identify that the region in parameter space where extreme events are observed; is sandwiched by two particular bifurcations: a bubbling transition and a blowout bifurcation [1]. Another striking feature of the events of the second category is the loss of synchrony significantly prior to the actual event.This allows us to use the phase difference between the oscillators as a precursor to such an extreme event [2].

Additionally, from a dynamical systems point of view, the delay-coupled FitzHugh-Nagumo system is interesting because it presents an example of amplitude death in coupled identical oscillators. Our analysis shows that the intricate interplay of the invariant subsets and their manifolds leads to the system showing extremely long transience before convergence to fixed point or chaotic attractors. This interplay also leads to the formation of riddled basins of attraction with tongue-like structures embedded in them [3, 4].

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Topic: **Complex modified projective synchronization of two chaotic complex nonlinear systems**

Speaker: **Gamal Mahmoud** (Assiut University, Egypt)

Abstract: In this talk, we present a novel type of synchronization called complex modified projective synchronization (CMPS) and study it to a system of two chaotic complex nonlinear 3-dimensional flows, possessing chaotic attractors. Based on the Lyapunov function approach, a scheme is designed to achieve CMPS for such pairs of (either identical or different) complex systems. Analytical expressions for the complex control functions are derived using this scheme to achieve CMPS. This type of complex synchronization is considered as a generalization of several kinds of synchronization that have appeared in the recent literature. The master and slave chaotic complex systems achieved CMPS can be synchronized through the use of a complex scale matrix. The effectiveness of the obtained results is illustrated by a studying two examples of such coupled chaotic attractors in the complex domain.
Numerical results are plotted to show the rapid convergence of modulus errors to zero, thus demonstrating that CMPS is efficiently achieved.

Topic: **Enhance capability and efficiency of cell mapping method through parallel computing and evolving probabilistic vector**

Speaker: **Jun Jiang** (Xi'an Jiaotong University, China)

Abstract: Cell mapping method, originated by C.S. Hsu, has been now developed to an effective numerical global analysis method that is capable to cover the invariant sets as well as the stable and unstable manifolds of nonlinear dynamical systems within a chosen domain of the state space. The accuracy of the computation depends highly upon the cell size achievable, which relies on if computation cost is tolerable and/or memory capability is sufficient. Thus the curse of dimensionality is the main obstacle for cell mapping methods to be applied in high dimensional systems with engineering background. The recent fast development in the hardware for high power computation provides the possibility to substantially enhance the capability of cell mapping method. In this talk, after brief review on the effective methods to improve the efficiency of cell mapping methods, such as subdivision technique and GPU parallel computing, a sub-domain synthesis method is introduced, which provides another way of parallel computing in the sub-domain scale (different from the scale of cell or subset). This approach makes the cell mapping method possible to take good

use of computation resource like a high performance workstation with multi-GPUs or a computing cluster with multi-nodes like GPU cloud, and benefits especially for the case that high accuracy (or resolution) is needed so as to identify the very closely located invariant sets, by which enormously huge memory capability is usually required. After that, an approach that presents a way to make cell mapping method efficiently capture the density dynamics of probability and possibility transition in high-dimensional and non-smooth systems is introduced after adopting the idea of evolving probabilistic vector to replace the fixed probabilistic vector in traditional cell mapping methods. Finally, as examples of application, the proposed methods of cell mapping are used to reveal a new mechanism of Wada boundary bifurcation, namely, boundary saddle-saddle collision, which is rigorously confirmed through the proof on basis of the schematically constructed equivalent topological structure of the manifolds, and to demonstrate either beneficial or detrimental effects of noise on a non-smooth rotor/stator rubbing system, that is, the noise may either decouple the rotor/stator under rubbing or induce destructive increase of rotor deflection depending on system parameters and noise intensity. This work is accomplished in collaboration with Professor Ling Hong, Dr. Zigang Li and Mr. Xiaoming Liu and supported by NSFC under grant No. 11772008.

Topic: **Complex network approach reveals global pattern of extreme-rainfall teleconnection**

Speaker: **Jürgen Kurths** (Potsdam Institute for Climate Impact Research, Humboldt-Universität zu Berlin,Germany)

Abstract: We analyse climate dynamics from a complex network approach. This leads to an inverse problem: Is there a backbone-like structure underlying the climate system? For this we propose a method to reconstruct and analyze a complex network from data generated by a spatio-temporal dynamical system. This approach enables us to uncover relations to global circulation patterns in oceans and atmosphere. We reveal the global coupling pattern of extreme-rainfall events by applying complex-network methodology to high resolution satellite data and introducing a technique that corrects for multiple-comparison bias in functional networks. We show that extreme-rainfall events in the monsoon systems of south-central Asia, east Asia and Africa are significantly synchronized. Moreover, we uncover concise links between southcentral Asia and the European and North American extratropics, as well

as the Southern Hemisphere extratropics. Analysis of the atmospheric conditions that lead to these teleconnections confirms Rossby waves as the physical mechanism underlying these global teleconnection patterns and emphasizes their crucial role in dynamical tropical-extratropical couplings.

This concept is then applied to Monsoon data; in particular, we develop a general framework to predict extreme events by combining a non-linear synchronization technique with complex networks. This way we analyze the Indian Summer Monsoon (ISM) and identify two regions of high importance. By estimating an underlying critical point, this leads to a substantially improved prediction of the onset of the ISM.

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Poster

Location: 2nd Floor

Leading authors	Title
Yongge Li	First passage time distribution in a moving parabolic potential with spatial roughness
Bin Pei	Strong Limit Results for Two-Time-Scale Neutral Stochastic Delay Partial Differential Equations Driven by Fractional Brownian Motions
Shaojuan Ma	
Wantao Jia	
Zhe Jiao	
Hong Ling	Switching Sensitive and Insensitive Responses in a Piecewise Smooth Rubbing Rotor Systems
Hua Li	
Jinzhong Ma	Predicting critical transitions in noise-induced bistable systems
Ronghua Huan	
Qi Liu	The influence mechanism of a random loading on an airfoil aerodynamic model with viscoelastic material property
Xuemei Liu	Heterogeneous diffusion and ergodicity breaking of particles in quenched disorder with Gaussian colored noise
Yanxia Zhang	Stochastic resonance and bifurcations in a harmonically driven tri-stable potential with colored noise
Hongge Yue	$L^P(P > 2)$-strong convergence of averaging principle for two-time-scale SDDEs with jumps under non-Lipschitz coefficients
Zhanqing Wang	α-stable Noise-Induced Coherence on a spatially extended FHN System
Xiaopeng Chen	
Yanmei Kang	Fractional Gaussian noise enhanced information capacity of nonlinear neuron models with binary input

Workshop Venue and Transportation

- **IWDNS-2019** will be held in **Le Garden Hotel**, Xi'an, China.

- **Hotel Address and Website**

  Address: Xi 'an labor south road no. 8, Lianhu District, Xi'an, China.
  Website: http://www.legardens.com/

- **The routes to the hotel**

  ● **From the Xi'an Xianyang International Airport:**

  Plan A - Shuttle bus: Airport-Traders Hotel line at West Gate or Airport-High tech Zone Zhicheng Park Hotel line. And then take the taxi or the city bus. Website of shuttle bus: http://www.xxia.com/site/traffic/airportBus

  Plan B - Taxi: about 50 minutes

  ● **From the Xi'anbei Railway Station:**

  Plan A - Public Transportation: Bus 201 to West gate of NWPU; Bus 206, 40 to South Laodong road station.

  Plan B - Taxi: about 40 minutes

  ● **From Xi'an Railway station:**

  Plan A - Public Transportation: Metro line 2 to Nanshaomen station, and then transfer to Bus 40 to South Laodong road station.

  Plan B - Taxi: about 30 minutes

Contact Us

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