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The Research Grants Council of Hong Kong
NSFC/RGC Joint Research Scheme
Joint Completion Report

(Please attach a copy of the completion report submitted to the NSFC by the Mainland researcher)

Part A: The Project and Investigator(s)

1. Project Title

Dynamical Network Mechanisms of Information Processing in Neural Systems
神經系統處理信息的動態網絡機制

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Mainland Team
Name of Principal Investigator *(with title)*	Prof. K. Y. Michael Wong	Prof. Si Wu
Post	Professor	Professor
Unit / Department / Institution	Physics, HKUST	State Key Laboratory of Cognitive Neuroscience and Learning, Beijing Normal University
Contact Information	phkywong@ust.hk	wusi@bnu.edu.cn
Co-investigator(s) *(with title and institution)*	Prof. Changsong Zhou, Hong Kong Baptist University	Prof. Zhangang Han, Beijing Normal University

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval *(must be quoted)*
Project Start date	1 January 2013		
Project Completion date	31 December 2016		
Duration *(in month)*	48 months		
Deadline for Submission of Completion Report	31 December 2017		

<u>Part B: The Completion Report</u>

5. Project Objectives

5.1 Objectives as per original application

1. To study how short-term plasticity among the synapses of neurons affects the dynamical behaviors of neuronal networks, and contributes to the processing of motional information.

2. To study how positive and negative feedbacks among the different layers of neural circuit modulate the network responses to external inputs, and contribute to the extraction of dynamical information from inputs.

3. To study how the intrinsic dynamics of complex neuronal networks is able to encode and store temporal information.

4. To study how large-scale hierarchical modular neuronal networks maintain local criticality and global stability, and hence optimize their computational capabilities involving spatiotemporal patterns.

5.2 Revised Objectives

Date of approval from the RGC: ____________________

Reasons for the change: ____
____

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

Objective 1:

1) **Dynamical effects of short-term plasticity [8,1,10,11,5].** We discovered that short-term plasticity can produce a rich spectrum of responses to external stimuli and thus have high potentials for temporal encoding, as demonstrated in resolution enhancement modeling. Other effects of short-term synaptic interactions, dynamical learning rules and multiplicative integration were studied, yielding excellent agreement with experiments.
2) **Delay compensation for real-time tracking [7,9,6]**. We found that dynamical synapses can compensate time delays that are ubiquitous in neural signal transmission and processing, enabling the system to perform real-time tracking of motional information. The general behavior is unified by fluctuation-response relations in statistical physics.
3) **Neural computation in a dynamical system with multiple time scales [18].** We studied how a neural system can orchestrate its rich short-term dynamics, with properly combined short-term facilitation, short-term depression, and spike-frequency adaptation, to realize seemingly contradictory computational requirements in different time scales.
4) **Short-term plasticity supporting dynamical information encoding [3,4]**. We showed that short-term plasticity in electrical synapses enables a neural system to respond fast to a novel stimulus and save energy to retain the information of the invariant stimulus after adaptation. It reconciles the long-standing debate in the field on rate versus correlation code.
5) **A model for asynchronous neurotransmitter release [10].** Based on the experimental data, we proposed a phenomenological model for asynchronous release of neurotransmitters at synapses. This is an important supplement to the conventional short-term plasticity model.
6) **A canonical model for neural information representation [19].**

Objective 2:

1) **Role of feedback loops [8].** We found that inhibitory feedback loops in multilayer networks influence network dynamics in the same way as short-term synaptic depression and spike-frequency adaptation do, unified by fluctuation-response relations.
2) **Modular neural networks [17,12].** We proposed a modular architecture for processing multisensory information. To integrate or segregate disparity-dependent information, we proposed a model with congruent and opposite reciprocal feedbacks between the modules.
3) **Encoding of multisensory prior [21].** We discovered how the joint multisensory prior is stored in the reciprocal feedbacks of the modular networks.

Objective 3:

1) **Temporal rhythm encoding in a scale-free network [2].** We proposed that a large scale-free neural network can encode the rhythm information of external inputs by employing simple template-matching, that is, in response to an external input, the network automatically selects a loop whose size matches the period of the input.
2) **Experimental relevance [3,4,16].** We found that in encoding a prolonged stimulation in bullfrogs' retina, the neural system may utilize concerted, but less active, firings of neurons to encode information, and dynamical electric synapses play a role. We also built a model describing the propagating neural activity during saccades in monkeys' eye.

Objective 4:

1) **Contradiction between SOC and complex oscillations are reconciled in E-I balanced module networks [13].** Furthermore, the dynamics support sensitive response of the resting brain states to external stimuli, consistent with our collaborator's monkey experiments.
2) **Co-organized neural information representation is cost-efficient [20].** We showed that multilevel cortical activity, including irregular firing of individual neurons, critical avalanches and oscillations can co-organize in a broad biologically realistic parameter region of modular networks and implies a fundamental principle of cost-efficiency.
3) **Interaction of firing patterns with synaptic plasticity [14,15].** We studied how spatial and temporal structures in the firing patterns in the multilevel cortical activity influences the diffusion of synaptic weights in the presence of synaptic plasticity, using firing pattern generation methods and the complex dynamical patterns in the E-I balanced neural networks.

Potential for further development of the research and the proposed course of action *(maximum half a page)*

1) Neural Circuits with Feedbacks

We have studied modular networks processing multisensory information. For networks with two or more modules, the modules compete with each other to yield the optimal output consistent with the prior distribution of information and the likelihood of the actual input. We propose to implement an optimal competition mechanism for this purpose. We will further consider the optimal network structure for time-dependent inputs. Next we will consider how features of the input information can be extracted from the dynamics of networks with multiple layers. This will be useful in the design of deep neural networks in artificial intelligence.

2) Hierarchical Modular Networks

We propose to further study the structure-function relationship in the human brain connectome about the unique features of hierarchical modular organization and critical states. Our preliminary results showed that hierarch modular organization and the critical states together maximize the functional diversity of the brain.

3) Cost-Efficient Computing

Currently there is a strong interest in developing brain inspired computing. The hierarchical modular network structure and cost-efficient critical neural dynamics may be used to develop efficient computing with low costs.

7. The Layman's Summary

(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

Our project obtained many successful results in the neural processing of dynamical information; the more representative ones are described below. 1) When the brain processes information that changes with time, delays are pervasive due to the time taken to transmit and process neural signals. We proposed an effective mechanism to achieve real-time tracking by utilizing the property that neurons become desensitized after prolonged firing. 2) When the brain receives information from different channels, it needs to integrate or segregate them depending on the disparity of the different inputs. We proposed a model with modules congruently or oppositely connected, inspired by the discovery of congruent and opposite cells in the brain. 3) It is mysterious that the neural system can memorize rhythms of duration much longer than the time scale of neural dynamics. We discovered that networks with scale-free connectivity and hard-to-activate hub neurons contain loops formed by low-degree neurons that can process rhythms with matching periods. 4) Neural systems consist of firing patterns resembling avalanches, which do not have characteristic time scales. It appears contradictory that they co-exist with finite-scale oscillations. We showed that they are reconciled in finite-sized modular networks in which synaptic excitations and inhibitions are balanced.

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s) (*bold the authors belonging to the project teams and denote the corresponding author with an asterisk**)	Title and Journal/ Book (*with the volume, pages and other necessary publishing details specified*)	Submitted to RGC (*indicate the year ending of the relevant progress report*)	Attached to this report (*Yes or No*)	Acknowledged the support of this Joint Research Scheme (*Yes or No*)	Accessible from the institutional repository (*Yes or No*)
Year of publication	Year of Acceptance (*For paper accepted but not yet published*)	Under Review	Under Preparation (*optional*)						
2013 [1]				C. C. Alan Fung*, He Wang, Kin Lam, K. Y. Michael Wong, and Si Wu	Resolution enhancement in neural networks with dynamical synapses, Front Comput Neurosci **7**, 73 (2013).	2013	No	Yes	Yes
2013 [2]				Y. Mi , X. Liao , X. Huang, L. Zhang, W. Gu, G. Hu* and S. Wu*	Long-Period Rhythmic Synchronous Firing in a Scale-Free Network. Proc Natl Acad Sci USA **110**, E4931-4936 (2013).	2017	Yes	Yes (NSFC side)	No
2013 [3]				L. Xiao, M. Zhang, D. Xing, P-J. Liang and S. Wu*	Shifted Encoding Strategy in Retinal Luminance Adaptation: from Firing Rate to Neural Correlation, J Neurophysiol **110**, 1793-1803 (2013).	2017	Yes	Yes (NSFC side)	No
2013 [4]				Xiao Lei, Zhang Danke, Li Yuanqing, Liang Peiji* and Wu Si*	Adaptive Neural Information Processing with Dynamical Electrical Synapses, Front Comput Neurosci **7**, 36 (2013).	2017	Yes	Yes (NSFC side)	No
2013 [5]				Danke Zhang, Yuanqing Li, Malte J Rasch*, Si Wu*	Nonlinear Multiplicative Dendritic Integration in Neuron and Network Models, Front Comput Neurosci **7**, 56 (2013).	2017	Yes	Yes (NSFC side)	No
2013 [6]				C. C. Alan Fung*, K. Y. Michael Wong, Hongzi Mao, and Si Wu	Fluctuation-Response Relation Unifies Dynamical Behaviors in Neural Fields, Phys Rev E **92**, 022801 (2015).	2017	Yes	Yes	Yes
2014 [7]				Yuanyuan Mi*, Yan Xia, C. C. Alan Fung, K. Y. Michael Wong, and Si Wu	Spike Frequency Adaptation Implements Anticipative Tracking in Continuous Attractor Neural Networks, Advances in Neural Information Processing Systems **27**, Z. Ghahramani et al. (eds), 505-513 (2014).	2014	No	Yes	Yes
2015 [8]				He Wang*, Kin Lam, C. C. Alan Fung, K. Y. Michael Wong, and Si Wu	A Rich Spectrum of Neural Field Dynamics in the Presence of Short-Term Synaptic Depression, Phys Rev E **92**, 032908 (2015).	2017	Yes	Yes	Yes

2015 [9]				C. C. Alan Fung* and S. Amari	Spontaneous Motion on Two-Dimensional Continuous Attractors, Neural Comput **27** 507-547 (2015).	2017	Yes	Yes	No
2015 [10]				Wang T, Yin L, Zou X, Shu Y, Rasch MJ *and Wu S*	A Phenomenological Synapse Model for Asynchronous Neurotransmitter Release, Front Comput Neurosci **9**, 153 (2015).	2017	Yes	Yes (NSFC side)	No
2015 [11]				Xuhui Huang, Zhigang Zheng, Gang Hu, Si Wu*, Malte J. Rasch*	Different propagation speeds of recalled sequences in plastic spiking neural networks, New J Phys **17**, 035006 (2015).	2017	Yes	Yes (NSFC side)	No
2016 [12]				Wenhao Zhang*, He Wang, K. Y. Michael Wong, and Si Wu	"Congruent" and "Opposite" Neurons: Sisters for Multisensory Integration and Segregation, Advances in Neural Information Processing Systems **29**, D. D. Lee et al. (eds), 3180-3188 (2016).	2017	Yes	Yes	Yes
2016 [13]				Shengjun Wang, Guang Ouyang, Jing Guang , Mingsha Zhang*, K.Y Michael Wong and Changsong Zhou*	Stochastic Oscillation in Self-Organized Critical States of Small Systems: Sensitive Resting State in Neural Systems, Phys Rev Lett **116**, 018101 (2016).	2017	Yes	Yes	Yes
2016 [14]				Zedong Bi* and Changsong Zhou*	Spike Pattern Structure Influences Synaptic Efficacy Variability Under STDP and Synaptic Homeostasis. I: Spike Generating Models on Converging Motifs, Front Comput Neurosci **10**, 14 (2016).	2017	Yes	Yes	No
2016 [15]				Zedong Bi* and Changsong Zhou*	Spike Pattern Structure Influences Synaptic Efficacy Variability Under STDP and Synaptic Homeostasis. II: Spike Shuffling Methods on LIF Networks, Front Comput Neurosci **10**, 83 (2016).	2017	Yes	Yes	No
2016 [16]				Xiaolan Wang, C.C. Alan Fung, Shaobo Guan, Si Wu*, Michael E. Goldberg, Mingsha Zhang*	Perisaccadic Receptive Field Expansion in the Lateral Intraparietal Area, Neuron **90**, 400-409 (2016).	2017	Yes	Yes	No
2016 [17]				Zhang, W. H., A.H. Chen, M.J. Rasch*, and S. Wu*	Decentralized Multisensory Information Integration in Neural Systems, J Neurosci **36**, 532-547 (2016).	2017	Yes	Yes (NSFC side)	No
2016 [18]				Yuanyuan Mi, Xiaohan Lin,and Si Wu*	Neural Computations in a Dynamical System with Multiple Time Scales, Front Comput Neurosci **10**, 96 (2016).	2017	Yes	Yes (NSFC side)	No
2016 [19]				Si Wu*, K. Y. Michael Wong, C. C. Alan Fung, Yuanyuan Mi, and Wenhao Zhang	Continuous Attractor Neural Networks: Candidate of a Canonical Model for Neural Information Representation, F1000Research 2016, 5(F1000 Faculty Rev):156 (2016).	2017	Yes	Yes (NSFC side)	No

2017 [20]				Dongping Yang, Haijun Zhou, and Changsong Zhou*	Co-emergence of Multi-scale Cortical Activities of Irregular firing, Oscillations and Avalanches Achieves Cost-efficient Information Capacity, PLoS Comput Biol **13**, e1005384 (2017).	2017	Yes	Yes	No
2017 [21]				He Wang*, Wenhao Zhang, K. Y. Michael Wong, and Si Wu	How the Prior Information Shapes Neural Networks for Optimal Multisensory Integration, Lecture Notes in Computer Science **10262**, F. Cong et al. (eds), 128-136 (2017).	2017	Yes	Yes	Yes

9. Recognized international conference(s) in which paper(s) related to this research project was/were delivered *(Please attach a copy of each delivered paper. All listed papers must acknowledge RGC's funding support by quoting the specific grant reference.)*

Month/Year/ Place	Title	Conference Name	Submitted to RGC *(indicate the year ending of the relevant progress report)*	Attached to this report *(Yes or No)*	Acknowledged the support of this Joint Research Scheme *(Yes or No)*	Accessible from the institutional repository *(Yes or No)*
June 2013 Hong Kong [22]	Multiple Representations in Neural Fields with Dynamical Synapses	The 16th Conference of the Physical Society of Hong Kong	2013	No	Yes	No
July 2013 Hong Kong [23]	Short-Term Synaptic Depression Enriches Responses to Stationary Stimuli in Continuous Attractor Neural Networks	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No
July 2013 Hong Kong [24]	Short-Term Synaptic Depression Enhances the Resolution of Population Codes	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No
July 2013 Hong Kong [25]	Continuous Attractor Neural Networks, Short-Term Synaptic Depression, and Delay Compensation	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No
July 2013 Hong Kong [26]	Trade-off between Structural Cost and Functional Value in the Connectivity and Activity of Neural Networks	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No
July 2013 Hong Kong [27]	Cost-Efficient Dynamical States Self-Organized by Balanced Excitation/Inhibition in Local Neuronal Networks	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No
July 2013 Hong Kong [28]	Mining Sequential Brain Cognitive Activity Components by Residue Iteration Decomposition (RIDE)	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No

July 2013 Hong Kong [29]	Formation of the Neural Networks under Multiple Constraints	HKUST IAS Program on Statistical Physics and Computational Neuroscience	2013	No	Yes	No
July 2013 Seoul [30]	Intrinsic Behavior Determines Responses to Stimuli in Neural Fields: Delay Compensation	XXV IUPAP International Conference on Statistical Physics (STATPHYS 25)	2013	No	Yes	No
July 2013 Beijing [31]	The Formation of Neural Connectivity under Multiple Constraints	Invited talk at the 1st International Workshop on Neuroimaging and Brain Connectum	2013	No	Yes	No
August 2013 Beijing [32]	Delay Compensation in Neural Fields: Intrinsic Behavior Determines Tracking Performance	Keynote Speech, Workshop on Intelligence Science (WIS 2013), IJCAI 2013 Workshops	2013	No	Yes	No
September 2013 Xiamen [33]	Less is More: Cost-Efficient Dynamical Modes in Balanced Neural Networks	Invited talk, International Conference "Emergent and Adaptive Behaviors in Soft Matter and Living Systems"	2013	No	Yes	No
December 2013 Lake Tahoe [34]	Reciprocally Coupled Local Estimators Implement Bayesian Information Integration Distributively	26th Annual Conference on Neural Information Processing Systems (NIPS 2013)	2017	Yes	Yes	No
June 2014 Hong Kong [35]	Fluctuation-response Relation in Neural Field Models	17th Conference of the Physical Society of Hong Kong	2014	No	Yes	No
June 2014 Beijing [36]	General Relation between Intrinsic Behavior and Response Performance in Neural Fields and Its Implications to Delay Compensation	Invited speech, Symposium on Neural Biology and Networks, 8th IUPAP International Conference on Biological Physics	2014	No	Yes	No
June 2014 Taipei [37]	How Your Brain Wanders Determines How Your Brain Tracks	Invited speech, 12th Taiwan International Symposium on Statistical Physics and Complex Systems	2014	No	Yes	No
November 2014 Washington DC [38]	A Model of Perisaccadic Receptive Field Remapping in LIP Predicts a Moving Wave of Activity across the Cortex	Neuroscience 2014	2014	No	Yes	No
December 2014 Hong Kong [39]	Cost-Efficiency in Neural Presentations	International Workshop on Computational Science and Engineering (IWCSE 2014)	2014	No	Yes	No
December 2014 Montreal [40]	A Synaptical Story of Persistent Activity with Graded Lifetime in a Neural System	27th Annual Conference on Neural Information Processing Systems (NIPS 2014)	2017	Yes	Yes	No
December 2014 Montreal [41]	Spike Frequency Adaptation Implements Anticipative Tracking in Continuous Attractor Neural Networks	27th Annual Conference on Neural Information Processing Systems (NIPS 2014)	2017	Yes	Yes	No
December 2014 Okazaki [42]	Physical Principles Unifying Dynamical Behaviors in Neural Fields	Invited speech, 14th Japan-China-Korea Joint Workshop on Neurobiology and Neuroinformatics, (NBNI2014)	2014	No	Yes	No
June 2015 Hong Kong [43]	Emergence of Complex Dynamics in Neural Fields with Short-Term Synaptic Depression	18th Conference of the Physical Society of Hong Kong	2017	Yes	Yes	No

June 2015 Hong Kong [44]	The Dynamics of Two-Layer Continuous Attractor Neural Network Model With Moving Stimulus	18th Conference of the Physical Society of Hong Kong	2017	Yes	Yes	No
December 2015 Hong Kong [45]	The Dynamics of Two-Layer Continuous Attractor Neural Network Model With Moving Stimulus	2015 International Symposium on Nonlinear Theory and its Applications (NOLTA 2015)	2017	Yes	Yes	No
December 2015 Hong Kong [46]	How Short-Term Synaptic Depression Reshapes Dynamics of Continuous Attractor Neural Networks	2015 International Symposium on Nonlinear Theory and its Applications (NOLTA 2015)	2017	Yes	Yes	No
December 2015 Hong Kong [47]	Modelling Optical Illusions from Radially Periodic Images	2015 International Symposium on Nonlinear Theory and its Applications (NOLTA 2015)	2017	Yes	Yes	No
December 2015 Hong Kong [48]	Sensitive Stochastic Oscillation in Self-Organized Critical States of Small Neural Systems	2015 International Symposium on Nonlinear Theory and its Applications (NOLTA 2015)	2017	Yes	Yes	No
December 2015 Hong Kong [49]	A Decentralized Architecture for Multisensory Neural Information Integration	2015 International Symposium on Nonlinear Theory and its Applications (NOLTA 2015)	2017	Yes	Yes	No
December 2015 Hong Kong [50]	Cost-Efficiency in Neural Presentations	Special Session "Nonlinear Data Analysis and Related Topics", International Symposium on Nonlinear Theory and Application (NOLTA 2015),	2017	Yes	Yes	No
December 2015 Hong Kong [51]	Stochastic Oscillation in Self-Organized Critical States of Small Systems: Sensitive Resting State in Neural Systems	Special Session "Information and Dynamics of Complex Networks", International Symposium on Nonlinear Theory and Application (NOLTA 2015),	2017	Yes	Yes	No
March 2016 Baltimore [52]	Distributed multisensory integration in a recurrent network model through supervised learning	American Physical Society March Meeting	2017	Yes	Yes	No
June 2016 Hong Kong [53]	Application of the Two-Layer Continuous Attractor Neural Network Model to Visual-Auditory Sensory Illusion	19th Conference of the Physical Society of Hong Kong	2017	Yes	Yes	No
June 2016 Hong Kong [54]	Temporal Integration in Layered Networks with Short-Term Synaptic Depression	19th Conference of the Physical Society of Hong Kong	2017	Yes	Yes	No
December 2016 Barcelona [55]	"Congruent" and "Opposite" Neurons: Sisters for Multisensory Integration and Segregation	29th Annual Conference on Neural Information Processing Systems (NIPS 2016)	2017	Yes	Yes	No
December 2016 Hong Kong [56]	Temporal Integration in Modular Neural Networks with Short-Term Synaptic Plasticity	9th Dynamics Days Asia-Pacific (DDAP9)	2017	Yes	Yes	No
December 2016 Hong Kong [57]	How the Prior Shapes Neural Structure for Optimal Multisensory Integration	9th Dynamics Days Asia-Pacific (DDAP9)	2017	Yes	Yes	No
December 2016 Hong Kong [58]	Modeling Visual-Auditory Sensory Illusion	9th Dynamics Days Asia-Pacific (DDAP9)	2017	Yes	Yes	No
December 2016 Hong Kong [59]	Neural Structure for Integrating Visual Signals with Those of Other Modalities	16th Japan-China-Korea Joint Workshop on Neurobiology and Neuroinformatics (NBNI 2016)	2017	Yes	Yes	No

December 2016 Hong Kong [60]	Co-Emergence of Multi-scale Cortical Activities of Irregular firing, Oscillations and Avalanches Achieves Cost-efficient Information Capacity	16th China-Japan-Korea Joint workshop on Neurobiology and Neuroinformatics (NBNI 2016),	2017	Yes	Yes	No
March 2017 New Orleans [61]	How the Prior Information Shapes Couplings in Neural Fields Performing Optimal Multisensory Integration	American Physical Society March Meeting	2017	Yes	Yes	No
March 2017 New Orleans [62]	Congruent and Opposite Neurons as Partners in Multisensory Integration and Segregation	American Physical Society March Meeting	2017	Yes	Yes	No
April 2017 Hangzhou [63]	Co-Emergence of Multi-scale Cortical Activities of Irregular firing, Oscillations and Avalanches Achieves Cost-efficient Information Capacity	Forum on Cognitive Science Frontier	2017	Yes	Yes	No
June 2017 Sapporo [64]	How the Prior Information Shapes Neural Networks for Optimal Multisensory Integration	14th International Symposium on Neural Networks (ISNN 2017)	2017	Yes	Yes	No
June 2017 Hong Kong [65]	Cross-Talks between Neural Pathways for Optimal Multisensory Information Processing	Best Student Poster Award, 20th Conference of the Physical Society of Hong Kong	2017	Yes	Yes	No
June 2017 Hong Kong [66]	Temporal Integration in Modular Neural Networks with Short-Term Synaptic Plasticity	20th Conference of the Physical Society of Hong Kong	2017	Yes	Yes	No
July 2017 Beijing [67]	Neural Systems Integrating Information from Different Channels	Invited talk, 9th Joint Meeting of Chinese Physicists Worldwide	2017	Yes	Yes	No
October 2017 Wuhan [68]	How Neural Systems Fuse Information from Different Channels	Invited talk, International Workshop on Statistical Physics and Mathematics for Complex Systems (SPMCS 2017)	2017	Yes	Yes	No
November 2017 Guangzhou [69]	Encoding Multisensory Information in Modular Neural Networks	24th International Conference on Neural Information Processing (ICONIP 2017)	2017	Yes	Yes	No
November 2017 Guangzhou [70]	The Dynamics of Bimodular Continuous Attractor Neural Networks with Moving Stimuli	24th International Conference on Neural Information Processing (ICONIP 2017)	2017	Yes	Yes	No
November 2017 Guangzhou [71]	Learning a Continuous Attractor Neural Network from Real Images	24th International Conference on Neural Information Processing (ICONIP 2017)	2017	Yes	Yes	No

10. Student(s) trained *(Please attach a copy of the title page of the thesis.)*

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Ouyang, Guang	PhD	September 2009	August 2013
Fung, Chi Chung Alan	PhD	September 2010	August 2013
Wang, He	MPhil	September 2011	September 2013
Xia, Yan	MSc	September 2012	July 2015
Wang, Tao	MSc	September 2012	July 2015

Zhang, Wenhao	PhD	September 2011	July 2016
Wang, He	PhD	October 2013	August 2017
Leung, Kai Yin	MPhil	September 2015	August 2017
Xiaohan Lin	MSc	September 2015	July 2018
Yan, Min	PhD	September 2013	August 2018

11. Other impact *(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)*

Through the research project on self-organized criticality in neural networks, close collaborations have been established with experimental neuroscientist Prof. Mingsha Zhang at Beijing Normal University and statistical physicist Prof. Haijun Zhou at the Institute of Theoretical Physics, the Chinese Academy of Sciences.