List of Invited Talks

[IG-11] **Giulio Casati** Classical and quantum chaos and control of heat flow

[IG-12] **Bai-lin Hao** Factorizable Languages Revisited: from Dynamics to Biology

[IG-21] **Kenneth Showalter** Collective Behavior in Addressable Excitable Media

[IG-22] **Rajarshi Roy** Chaotic yet consistent? Synchronization of driven nonlinear (optical) systems

[IG-31] **Yoshiki Kuramoto** External noise causes complex effective dynamics in pattern-forming systems

[IA-11] **Eli Ben-Naim** Parity and Predictability of Competitions: Nonlinear Dynamics of Sports

[IB-11] **Takahisa Harayama** Nonlinear Dynamics and Optical Sensing Application of 2D Microcavity Lasers

[IA-21] **Adilson Enio Motter** Universality and Optimization in the Synchronization of Complex Networks

[IB-21] **Kyoung Jin Lee** Alternans and Complex-oscillatory Cardiac Spiral Waves

[IA-31] **Bing-Hong Wang** Traffic dynamics based on local routing protocol and efficient routing strategy on complex networks

[IB-31] **Choy-Heng Lai** Noise Filtering in Chaos Synchronization

[IA-41] **Chin-Kun Hu** Numerical approach to structure, folding, and unfolding of proteins

[IA-42] **Robert L Dewar** Quantum chaos analysis of the ideal interchange spectrum in a stellarator

[IB-41] **Stefano Boccaletti** Synchronization in static and dynamic networks

[IA-51] **Kunihiko Kaneko** Biological Fluctuation, Adaptation and Evolution

[IA-52] **J. Michael Herrmann** Stability of Singularities in Cortical Maps

[IB-51] **Bambi Hu** Recent Study of the Frenkel-Kontorova Model

[IA-61] **Kazuyuki Aihara** Dual Information Coding with Spatio-Temporal Neuronal Spikes

[IB-61] **Roland Ketzmerick** Dynamical Tunneling in a Mixed Phase Space

[IA-71] **Enrico Scalas** Growth and allocation of resources in Econophysics

[IB-71] **Moo Young Choi** Dynamic model for failures in biological systems: criticality and resonance

[IA-81] **Heiko Rieger** Dissipation in strongly disordered quantum magnets

[IB-81] **Anna Lin** Probing chemical communication between neuron-glial cell networks

[IB-82] **Chi-Keung Chan** Connectivities induced Synchronization in Cortical Neuronal Networks

List of Contributed Talks

[CA-11] **Kwok Yee Michael Wong** Stabilizing Aggregates in the Dynamics of a Competing Population

[CA-12] **Hyun Keun Lee** Equivalence of operator-splitting schemes for the numerical integration of the Langevin equation

[CB-11] **Susumu Shinohara** Highly directional emission in stadium-cavity lasers

[CB-12] **Sang-Bum Lee** Observation of universal output directionality of single modes with high cavity quality factors in a deformed microcavity

[CA-21] **Byungnam Kahng** Synchronization transition in scale-free networks : heterogeneously coupled case

[CA-22] **Tao Zhou** How to enhance network synchronizability

[CA-23] **Woo-Sung Jung** Opinion Dynamics on Clustered Networks

[CB-21] **Dmitry Postnov** Synchronization and noise controlled firig patterns in potassium driven neural networks

[CB-22] **Woochang Lim** Transition from Weak to Strong Coherence Resonance in Coupled Type-I Neurons

[CB-23] **Sreedhar B Dutta** Dynamically perturbed n-vector model

[CA-31] **Hawoong Jeong** Price of Anarchy in Complex Networks

[CA-32] **Petter Holme** Local symmetries in complex networks

[CB-31] **Shuguang Guan** Understanding synchronization induced by "common noise"

[CA-41] **Wonho Jhe** Study of Nonlinear Dynamics and Collective Effects with Cold Atoms

[CB-41] **Jae Dong Noh** Interacting particle systems in complex networks

[CB-42] **Meesoon Ha** Finite-Size Scaling in Complex Networks

[CA-51] **Pik-Yin Lai** Growth model of Neuronal Network in vitro

[CB-51] **Jacob Szeftel** Microwave acoustoelectric soliton in piezoelectric semiconductors

[CB-52] **Baowen Li** Effective phonons in anharmonic lattices: anomalous vs normal heat conduction

[CB-53] **Jasmina Tekic** Dynamical mode locking in commensurate structures with an asymmetric deformable substrate potential

[CA-61] **Seung Kee Han** Asymmetric coupling from visual evoked theta to ongoing alpha induces the alpha phase resetting

[CA-62] **Myoung Won Cho** Theoretical approach to neural network regulations for spike-based Hebbian learning

[CB-61] **Hirokazu Aiba** Analysis of the Nodal Structure for a Nonintegrable Two-Dimensional Quartic Oscillator

[CB-62] **Nark Nyul Choi** Oscillations in photoionization of two-electron atoms

[CA-71] **Ming-Chya Wu** Phase distribution and phase correlation of financial time series

[CA-72] **Jae Woo Lee** Multiscaling behaviors of the Korean stock market

[CA-73] **Sudhir Jain** Persistence in Random Bond Ising Models of a Socio-econo Dynamics in High Dimensions and Financial Markets

[CA-74] **Kyungsik Kim** Two-phase herd behavior in financial markets

[CB-71] **Ravindra Eknath Amritkar** Spatial synchronizatin and extinction of species

[CB-72] **Hyunsuk Hong** Entrainment transition in coupled random frequency oscillators

[CB-73] **Jin-Qing Fang** A Unifying Hybrid Attachment Model and Its Effects of Hybrid Ratio on Topological and Dynamical Properties

[CA-81] **Beom Jun Kim** Quantum phase transition and finite-size scaling

[CA-82] **Sang Wook Kim** Pumps operating at the boundary between classical and quantum world

List of Poster Presentations

[PB-01] **Tae Yun Kim** Pharmacological effects of a novel Na+ channel agonist, Dimethyl Lithospermate B on the wave dynamics of cultured cardiac tissue

[PB-02] **Yu-Sheng Chou** Bursting of neurons induced by inhibitory mechanism

[PB-03] **Sheng-Cheng Wang** Long Range Correlation and Possible Electron Conduction Through DNA Sequences

[PB-04] **Cuong Nguyen** Operon-like motif structure in transcriptional regulation of Saccharomyces cerevisiae

[PB-05] **Li Cheng-Han** Synchronization during the Growth Myocardial Cultures

[PB-06] **June Hoan Kim** Dynamics in growing networks of cortical neurons

[PB-07] **Jinhee Hong** Puzzling Origin of the Circadian Oscillation of Cytosolic Calcium Level in Rat Suprachiasmatic Nucleus

[PB-08] **Hongseok Kim** Ca2+ dynamics in pancreatic duct epithelial Cell

[PB-09] **Takahito Mitsui** Geometric Resonance in the Refractory-Activation Oscillator Model for the Cross-bridge Formation in the Actomyosin System

[PB-10] **Ryu Jea Woon** Phase Specific Activated Modules from Protein Interaction Network of Yeast Cell Cycle

[PB-11] **Pan-Jun Kim** Emergence of Chaotic Itinerancy in Simple Ecological System

[PB-12] **Byeongha Jeong** Investigation on the mechanical properties of macrophages

[PB-13] **Jin-Sung Park** Neuron-Glia Interaction in Cultured Network of Rat Cortex

[PB-14] **UnCheol Lee** The reconstruction of the qualia space based on multi-channel electroencephalograms and the dynamic properties of the consciousness trajectory.

[PC-01] **Gab Jin Oh** Fractality in Weighted Networks

[PC-02] **Chang-Woo Shin** Self-organized Criticality and Scale-free Properties in Emergent Functional Neural Networks

[PC-03] **Po-Han Lee** The Topological Properties of Protein-protein Interaction Networks

[PC-04] **Jeongkyu Shin** Complex networks with broadcasted nodes

[PC-05] **Jin Seop Kim** Fractality and self-similarity in scale-free networks

[PC-06] **Young-Ho Eom** Evolution of Weighted Complex Networks: Empirical Analysis and Modelling

[PC-07] **Seung-Woo Son** Relaxation dynamics of the synchronization on scale-free networks

[PC-08] **Dong Uk Hwang** A model of growing hierarchical scale-free networks

[PC-09] **Sang Hoon Lee** Effects of substrate network topologies on competition dynamics

[PC-10] **Sang Hoon Lee** Statistical properties of sampled networks

[PC-11] **Hawoong Jeong** Collaborative Blog Spam Filtering Using Adaptive Percolation Search

[PD-01] **Jin-Sung Park** Dynamics of Bubble Shaped Line Defects in Period-2 Oscillatory Media

[PD-02] **Takashi Matsumoto** Effects of Non-Stationary processes and Position Dependen Flipping Rate on an On-Off Ratchet

[PD-03] **Amadeo Benavent-Climent Sr.** Nonlinear dynamics of beam-column connections coupled with hysteretic dampers: Direct analysis and response prediction based on energy considerations

[PD-04] **Sang Hun Lee** Chaotic stimulated Brillouin scattering near the threshold in a fiber

[PD-05] **Woo-Sic Son** Control of deterministic ratchet system via extended delay feedback

[PD-06] **Shigeru Ajisaka** Method of Asymptotics beyond All Orders and Restriction on Maps

[PD-07] **Myoung-Sun Heo** Nonlinear Dynamics Study with Driven Cold Atoms

[PD-08] **Adilson Enio Motter** Chaos Theory for Relativistic Dynamical Systems

[PD-09] **Daun Jeong** Rotational dynamics of a diatomic solute in the room-temperature ionic liquid 1-ethyl-3-methylimidazolium hexafluorophosphate

[PD-10] **Miki U. Kobayashi** Determination of Chaotic Dynamical Correlations in Terms of Unstable Periodic Orbits

[PD-11] **Naoya Fujiwara** Pattern dynamics in a rotating field

[PD-12] **Takuma Akimoto** A study of correlation function in non-hyperbolic dynamical systems

[PD-13] **Hiromichi Suetani** Pulse Dynamics in Coupled Excitable Fibers: Crossing, Switching, Overtaking, and Spatio-Temporal Chaos

[PD-14] **Shiquan Wan** A new method for discerning the property of climate jump in China around the end of 1970s

[PD-15] **Shiquan Wan** Nonlinear Dynamical Structure of precipitation in China and its Regional Climate Characters

[PD-16] **Zhi-Qiang Gong** On Performance Differences of EMD and WD in the Nonlinear Time Series Analysis

[PD-17] **Zhi-Qiang Gong** The Characteristics of power-law decay in Precipitation time series

[PD-18] **Zhi-Qiang Gong** Detecting the Abrupt Change of the Dynamical Structure of Non-Linear Time Series

[PD-19] **Zhi-Qiang Gong** Detecting Characters of North China and Global Climate Changes

[PE-01] **Kwan Ho Lee** Antipersistent Effects in the Dynamics of a Competing Population

[PE-02] **Kyungsik Kim** Detrended Fluctuation Analysis in Financial Exchange Market

[PE-03] **Kwok Yee Michael Wong** Cascades of Dynamical Transitions in an Adaptive Population

[PE-04] **I. C. Chen** Persistence probability analysis in major financial indices

[PE-05] **Joongwoo Brian Park** Compexity analysis of stock market

[PE-06] **Seung Ki Baek** Business cycles and crises

[PE-07] **Woo-Sung Jung** Group Dynamics of Japanese Market

[PE-08] **Woocheol Jun** Measuring the degree of common trends between multivariate time series

[PE-09] **Gab Jin Oh** Understanding Cross-Correlation in Financial Market.

[PN-02] **Ravindra Amritkar** Delay correlation matrices

[PN-03] **Gwang-ok Hur** Statistical properties of δ-kicked quantum rotors

[PN-04] **Kenji Orihashi** Spatio-temporal Chaos of three variable competitive Lotka-Voltera reaction diffusion equation

[PN-05] **Jung-Wan Ryu** Directional interacting whispering gallery modes in coupled dielectric microdisks

[PN-06] **Hyuk Kang** Phase Slips in Superconduting Wires

[PN-07] **Woochang Lim** Transition from Strong to Weak Coherence Resonance in Excitable Phase Models

[PN-08] **Takuya Ohzono** Effect of gradual change in compressive direction on microwrinkle patterns

[PN-09] **Syamal Kumar Dana** Experimental evidence of phase-slip bifurcation in delay coupled Chua oscillators

[PN-11] **Hang-Hyun Jo** Self-Organized Criticality in a Simple Opinion Dynamical Model

[PN-12] **Youngkyun Jung** Flow of Lennard-Jones Fluids in Nanochannel

[PN-13] **Takehiko Horita** Stochastic model of chaotic phase synchronization

[PN-14] **Hyungtae Kook** Phase Model Analysis of Coupled Neuronal Oscillators with Multiple Connections

[PN-15] **Jeong-Bo Shim** Wave-Particle Duality in an Open Chaotic System: a Quadrupolar Deformed Microcavity

[PN-16] **Ruey-Tarng Liu** Oscillatory Turing patterns in a simple reaction-diffusion system

[PN-17] **Chung Feifang** Simulation and experiment of horizontal size segregation

[PN-18] **Katsuya Ouchi** Domain size distribution in the TDGL system driven by the dichotomous Markov noise

[PN-19] **Sang-Gui Lee** Bifurcation Analysis of Mode-locking Structure in a Hodgkin-Huxley Neuron under Sinusoidal Current

[PN-20] **Jung-Hyo Jo** $1/f$ spectrum in a fiber bundle model

[PN-22] **Hiroyasu Ando** Self-Adaptation to Stable Periodic States in Chaotic Systems

[PN-23] **Jin Tao** Spatial Shift of Soliton in One-Dimension Lattice

[PN-24] **Tomoko Tanaka** Shape Parameter Dependence of Emission Patterns from the Oval-Billiard Microcavity Laser Diodes

[PN-26] **Dae Sic Lee** Transition from phase synchronization to lag synchronization in coupled lasers

[PO-01] **Manhee Lee** General Theory of Amplitude-Modulation Atomic Force Microscopy

[PO-02] **Chang Hie Hahn** First Observation of KAERIs 10MeV Electron Beam Signals by CNU GEM Detector

[PO-03] **Muhan Choi** Control of Emission light in Quasi-Stadium Micro-Cavity Laser Diodes

[PO-04] **Soya Shinkai** The Lempel-Ziv Complexity in Infinite Ergodic System

[PO-05] **Kourosh Nozari** Fuzzy Structure of Spacetime in Planck Scale

[PO-06] **Kourosh Nozari** Dynamics of Harmonic Oscillator within Generalized Uncertainty Principle

[IG-11] Classical and quantum chaos and control of heat flow

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The understanding of the underlying dynamical mechanisms which determines the macroscopic laws of heat conduction is a long standing task of non-equilibrium statistical mechanics. Recent years have witnessed some important progress in this direction even though a satisfactory understanding is, so far, unavailable. For example,after two decades of debates, it is now clear that exponential local instability is not a necessary condition for the validity of Fourier law. A better understanding of the mechanism of heat conduction may also lead to potentially interesting applications based on the possibility to control the heat flow. Indeed, a model of thermal rectifier has been recently proposed in which heat can flow preferentially in one direction. Although this model is far away from a prototype realization, it is based on a mechanism of very general nature and, as such, is suitable of improvement and may eventually lead to real applications. More recently, a different thermal diode model has been proposed in which, even though the underlying physical mechanism is similar to the previous model, there is a new crucial element which allows to improve the efficiency by more than two orders of magnitude. Finally we briefly discuss the possibility to build a thermal transistor. Of particular interest is the problem, almost completely unexplored, of the derivation of Fourier law from quantum dynamics. To this end we discuss heat transport in a model of a quantum interacting spin chain and we provide clear numerical evidence that Fourier law sets in above the transition to quantum chaos.

- Keywords: nonlinear dynamics, chaos, quantum chaos,transport properties

[IG-12] Factorizable Languages Revisited: from Dynamics to Biology

Bai-lin Hao

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A language is called factorizable if any substring of its word also belongs to the language. Sequences from a symbolic dynamics viewed as a language come under this definition. A few years ago we defined a factorizable language from a complete genome and, using this approach, solved the problem of counting true and redundant avoided strings in the genome. Recently, we encounter the problem of decomposition of a protein sequence and reconstruction of the sequence from its constituent K-tuples. The problem of uniqueness of the reconstruction again leads to a factorizable language. We will review this aspect of formal language theory on these examples.

[IG-21] Collective Behavior in Addressable Excitable Media

Kenneth Showalter

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We discuss two topics of collective behavior in the context of excitable media models, swarming behavior and spatiotemporal networks. Studies of controlling reaction-diffusion waves with realistic excitability potentials are described. We also describe a study of dynamical networks in the photosensitive Belousov-Zhabotinsky reaction. We model local nearest-neighbor interactions by the spread of reaction-diffusion waves, while nonlocal excitations are described by nondiffusive jumps along shortcuts defined in the medium.

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[IG-22] Chaotic yet consistent? Synchronization of driven nonlinear (optical) systems

Rajarshi Roy, Atsushi Uchid , and Ryan McAllister

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Abstract: Dynamical systems respond to external signals in several different ways. We explore experimentally how complex waveforms (chaotic or noisy) with different characteristics generate different responses in driven nonlinear optical systems. We look first at generalized synchronization, when the system is driven by a chaotic waveform recorded from the system itself. We then enlarge the set of drive signals to include noisy waveforms. The notion of consistency describes how a system may respond to either type of repetitive driving, starting from different initial conditions. Numerical simulations of mathematical models of the optical systems reveal the role of internal noise, dynamical instabilities as well as the influence of drive waveform design on the consistency of response. We point out possible applications of these ideas to dynamical non-destructive testing of structures and devices - biological, mechanical, electronic and optical.

- Keywords: synchronization, consistency

[IG-31] External noise causes complex effective dynamics in pattern-forming systems

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External noise applied to pattern-forming systems generally changes their effective dynamics. Contrary to our intuition that the average pattern would become simpler than in the absence of noise, there exists a counter example in which non-turbulent system becomes turbulent due to noise, where the level of turbulent fluctuations is by far larger than the noise level. The particular class of systems studied is the oscillator systems with non-local coupling for which the effective dynamics can be defined unambiguously. Our theory makes full use of the two representative methods of reduction, namely the phase reduction and the center-manifold reduction. They are applied to a non-linear functional Fokker-Planck equation, i.e., a deterministic evolution equation for the space-time dependent phase distribution function. The effective evolution equation is derived near the onset of collective oscillation and also far from it but close to the onset of phase turbulence. Validity of our theory is confirmed by comparison with some numerical results.

- Keywords: noise, turbulence, coupled oscillators, phase reduction, center-manifold reduction, Fokker-Planck equation

[IA-11] Parity and Predictability of Competitions: Nonlinear Dynamics of Sports

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Statistical analysis of the results of sports competitions in the five major sports leagues in England and the United States is presented. The parity among teams is measured by the variance in the winning fraction from season-end standings data the predictability of games is characterized by the frequency of upsets from game results data. A mathematical model in which the underdog team wins with a fixed upset probability is used to relate the parity among teams with the predictability of the games. Theoretical analysis of the nonlinear evolution equations is performed using scaling methods. A generalization of this model to multi-player games will be discussed as well.

- Related: http://arxiv.org/abs/physics/0512143; http://arxiv.org/abs/physics/0512144

[IB-11] Nonlinear Dynamics and Optical Sensing Application of 2D Microcavity Lasers

Takahisa Harayama

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Various kinds of devices such as lasers and musical instruments utilize stationary wave oscillations in resonant cavities. In order to maintain the stationary oscillation in these devices, nonlinearity is essential in the mechanism for balancing the pumping of the external energy and the decay of the wave of the quasi-stable resonance in the resonant cavity. Besides, the interaction between nonlinearities and the morphology of the boundary condition imposed on a resonating wave system by the shape of the cavity is also very important for determining the modes of oscillation.

One-dimensional simple shapes have been used for laser cavities because they are suitable for fabrication as well as application of directional emission. However, recent advances in processing technology of dry-etching for semiconductor laser diodes have made it possible to fabricate two-dimensional (2D) microcavity lasers of arbitrary 2D shapes with potential applications of 2D emission of laser light in optical communications, optical integrated circuits, and optical sensing.

We will present the theory of 2D mcirocavity lasers and their application for optical sensors.

[IA-21] Universality and Optimization in the Synchronization of Complex Networks

Adilson Enio Motter, Takashi Nishikawa, Changsong Zhou, and Juergen Kurths

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Systems as diverse as power grids, singing crickets, and firing neurons have a tendency to operate in synchrony. The synchronization of these and other complex systems can be understood within a common framework based on the study of coupled oscillators. The oscillators represent the dynamical unities of the system—power stations, crickets, neurons—and a network of couplings accounts for interactions between oscillators. The ability of the system to synchronize has been long known to depend strongly on the complex structure of the network of couplings. Realistic networks display not only a complex topological structure, but also a heterogeneous distribution of weights in the connection strengths. Here I discuss the synchronizability of weighted networks of oscillators. First I show that the synchronizability of random weighted networks with large minimum degree is determined by two leading parameters: the mean degree and the heterogeneity in the distribution of weighted in-degrees, where the weighted in-degree of a node, defined as the total strength of input connections, is a natural combination of topology and weights. Then I discuss the problem of maximizing the synchronizability of any network by assigning weights and directions to the links of a given interaction topology. The results provide a possibility for the control of synchronization in complex networks by the manipulation of few parameters.

- Keywords: complex networks, synchronization, weighted networks, directed networks

[IB-21] Alternans and Complex-oscillatory Cardiac Spiral Waves

Kyoung Jin Lee, Tae Yun Kim, Seongmin Hwang, Jin Sung Park, and Sung Jae Woo

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Spatio-temporal wave activities in excitable heart tissues have long been the subject of numerous studies because they underlie different forms of cardiac arrhythmias. Among others, understanding the dynamics and the instabilities of cardiac spiral waves (or reentries) have become very important since they can cause reentrant tachycardia and their subsequent transitions to fibrillation. While many aspects of cardiac spiral waves have been investigated through experiments and model simulations, their complex properties are far from being well understood. Here, we show that intriguing complex-periodic such as period-2, period-3, period-4, or aperiodic reentries can arise in mono-layer tissues of cardiac cell culture *in vitro*. These striking observations have a very good analogy in nonlinear chemical reaction-diffusion systems. I will discuss a few different mechanisms responsible for these unusual states.

- Keywords: alternans, reentries, cardiac fibrillation
- Related: 1. J. -S. Park, S. -J. Woo, and K. J. Lee, Phys. Rev. Lett. bf 93, 98302 (2004).
2. S. -m. Hwang, K. Yea, K. J. Lee, Phys. Rev. Lett. bf 92, 198103 (2004).
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[IA-31] Traffic dynamics based on local routing protocol and efficient routing strategy on complex networks

Bing-Hong Wang

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We propose a new routing strategy to improve the transportation efficiency on complex networks. Instead of using the routing strategy for shortest path, we give a generalized routing algorithm to find the so-called efficient path, which considers the possible congestion in the nodes along actual paths. Since the nodes with largest degree are very susceptible to traffic congestion, an effective way to improve traffic and control congestion, as our new strategy, can be as redistributing traffic load in central nodes to other non-central nodes. Simulation results indicate that the network capability in processing traffic is improved more than 10 times by optimizing the efficient path, which is in good agreement with the analysis.

We propose a packet routing strategy with a tunable parameter α based on the local structural information of a scale-free network. As free traffic flow on the communication networks is key to their normal and efficient functioning, we focus on the network capacity that can be measured by the critical point of phase transition from free flow to congestion. Simulations show that the maximal capacity corresponds to $\alpha \approx -1$ in the case of identical nodes delivering ability. To explain this, we investigate the number of packets of each node depending on its degree in the free flow state and observe the power law behavior. Other dynamic properties including average packets traveling time and traffic load are also studied. Inspiringly, our results indicate that some fundamental relationships exist between the dynamics of synchronization and traffic on the scale-free networks.

We propose a new routing strategy on the basis of the so-called next-nearest-neighbor search strategy by introducing a preferential delivering exponent α. It is found that by tuning the parameter α , the scale-free network capacity measured by the order parameter is considerably enhanced compared to the normal next-nearest-neighbor strategy. Traffic dynamics both near and far away from the critical generating rate R_c are discussed, and it is found that the behavior of $1/f$-like noise of the load time series not only depends on the generating rate R but also on the parameter α. We also investigate R_c as functions of C (capacity of nodes), m (connectivity density) and N (network size). Due to the low cost of acquiring next-nearest-neighbor information and the strongly improved network capacity, our strategy may be useful for the protocol designing of modern communication networks.

- Keywords: local routing protocol, efficient routing strategy, traffic dynamics on complex networks
- Related: Wen-Xu Wang, Bing-Hong Wang, Chuan-Yang Yin, Yan-Bo Xie, and Tao Zhou, Traffic dynamics based on local routing protocol on a scale-free network, Physical Review E 73-2(2006)026111
C.-Y. Yin,B.-H. Wang,W.-X. Wang,G.Yan,and H.-J.Yang Traffic dynamic

[IB-31] Noise Filtering in Chaos Synchronization

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In a chaotic synchronization system whose driving signal is exposed to channel noise, the estimation of of the drive system states can be greatly improved by applying dynamical noise filtering to the response system states. If the noise is bounded in a certain range, the estimation errors can be made arbitrarily small. This property can be used in designing an alternative digital communication scheme. An analysis based on the conditional entropy justifies the application of dynamical noise filtering in generating quality synchronization.

- Keywords: noise filtering; chaotic synchronization

[IA-41] Numerical approach to structure, folding, and unfolding of proteins

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In this talk, I briefly review some recent developments in numerical approach to structure, folding, and unfolding of proteins. The topics under discussion include:

(1) developments of algorithms and computer packages for all-atom simulations of proteins [1],

(2) parallel tempering simulations of HP-36 [2],

(3) calculation of protein volume V and surface area A by analytic equations [3],

(4) Go-like model approach to folding of hbSBD–a protein with 52 amino acides, and protein folding rates [4].

(5) unfolding and refolding of immunoglobulin domain I27 and ubiquitin [5].

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- Keywords: protein folding, all-atom model, hbSBD, I27, ubiquitin

[IA-42] Quantum chaos analysis of the ideal interchange spectrum in a stellarator

Robert L Dewar, Carolin Nuehrenberg, and Tomoya Tatsuno

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The eigenmode spectrum is a fundamental starting point for the analysis of plasma stability and the onset of turbulence, but the characterization of the spectrum even for the simplest plasma model, ideal magnetohydrodynamics (MHD), is not fully understood. This is especially true in configurations with no continuous geometric symmetry, such as a real tokamak when the discrete nature of the external magnetic field coils is taken into account, or the alternative fusion concept, the stellarator, where axisymmetry is deliberately broken to provide a nonzero winding number (rotational transform) on each invariant torus of the magnetic field line dynamics (assumed for present purposes to be an integrable Hamiltonian system).

Quantum (wave) chaos theory provides tools for characterizing the spectrum statistically, from the regular spectrum of the separable case (integrable semiclassical dynamics) to that where the semiclassical ray dynamics is so chaotic that no simple classification of the individual eigenvalues is possible (quantum chaos).

Using the ideal MHD code CAS3D, we have constructed a data set of several hundred growth-rate eigenvalues for an interchange-unstable three-dimensional stellarator equilibrium with a rather flat, nonmonotonic rotational transform profile. Statistical analysis of eigenvalue spacings shows evidence of quantum chaos. We contrast this with the distribution of eigenvalue spacings in a cylindrical model.

- Keywords: quantum chaos MHD spectrum
- Related: http://wwwrsphysse.anu.edu.au/∼rld105/_images/ICNSP05_Dewar.pdf

[IB-41] Synchronization in static and dynamic networks

Stefano Boccaletti, Dong-Uk Hwang, Mario Chavez, Vito Latora, Andreas Amann, Juergen Kurths, and Louis M. Pecora

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Coupled biological and chemical systems, neural networks, social interacting species, the Internet and the World Wide Web, are only a few examples of systems composed by a large number of highly interconnected dynamical units. Many relevant questions arise when studying complex networks' dynamics, such as learning how a large ensemble of dynamical systems that interact through a complex wiring topology can behave collectively. During my talk I will describe a series of issues regarding the relationships between the topology of a network wiring and its propensity to give rise to synchronization processes. Precisely, I will discuss the general problem of stability of a synchronized motion in a generic network of coupled dynamical units, and show that one can introduce suitable indicators that measure the propensity of a given topology to give rise to synchronization, independently on the specific dynamical evolution taking place on each node of the network. Furthermore, I will show how it is possible to maximize or enhance the propensity for synchronization in both static and dynamically varying complex networks.

[IA-51] Biological Fluctuation, Adaptation and Evolution

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I present general relationships between fluctuations and basic biological fearues such as adaptaion and evolution, both from theory and experiments.

First, I briefly discuss universal statistical laws of chemical abundances in a cell that sustains recursive production. From theoretical studies of simple protocell models, discovered are a ower law in the gene expressions and log-normal distribution of the abundances of each chemical. Experimental verification of these aws is also presented.

Second, to discuss relevance of this phenotypic fluctuations to volution, fluctuation-dissipation theorem in physics is generalized, to obtain relationship between phenotypic fluctuations and genetic evolution. The proposed relationship is confirmed both in xperiments and in model simulations. General relationship between phenotypic fluctuation and genetic variance is derived from evolutionary stability hypothesis, following the Einstein's spirit on micro-macro consistency in Brownian motion theory. This relationship is confirmed in models of catalytic reaction dynamics and gene network. I also discuss a possible answer to the question on 'Nature or Nurture'.

Third, a novel adaptation mechanism in a cell is proposed, that does not rely on specific signal transduation network but takes advantage of the stochasticity in gene expression, to show that the mechanism works as a universal property of a growing cell.

- Related: Life: An Introduction to Complex Systems Biology, Springer (to appear, July 2006)

[IA-52] Stability of Singularities in Cortical Maps

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Contour detecting neurons in the mammalian visual cortex tend to represent various stimulus parameters in an orderly fashion,however in a configuration with abundant pinwheel-like singularities. Relying essentially only on the intrinsic symmetries of the system, we developed a phenomenological model of Swift-Hohenberg type as well as a microscopically derived self-organizing-map model. Both models offer an explanation of the presence and stability of pinwheels based on non-local interactions. Furthermore, the results of a comprehensive analysis of experimental data allow us to study the influence of genetical factors on the periodicity of the map.

- Keywords: Self-organizing map, Swift-Hohenberg model, orientation map, visual cortex, pinwheel

[IB-51] Recent Study of the Frenkel-Kontorova Model

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We'll present our recent study of the Frenkel-Kontorova model. In particular, we'll discuss heat conduction in the classical FK model and the density renormalization group study of the quantum FK model.

- Keywords: Frenkel-Kontorova, heat condcution, density matrix renormalization group

[IA-61] Dual Information Coding with Spatio-Temporal Neuronal Spikes

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Since neurons are nonlinear devices even with chaotic dynamics [1],[2], neural networks generate rich dynamical behaviors with spatio-temporal spikes, which are believed to carry information in the brain. On the contrary to the hot issue on neural coding, namely rate coding versus temporal coding, it is possible to show by a simple neural network model that the two information coding schemes are not necessarily alternative but can be utilized dually depending on some parameters such as intensity of background noise, shared connectivity, and heretogeniety of neurons[3],[4]. I will review this dual coding hypothesis especially from the viewpoint of dynamical systems theory. If I have time, I will also report possible effects of depolarizing GABA actions and synaptic plasticity on neural coding[5],[6].

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[IB-61] Dynamical Tunneling in a Mixed Phase Space

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The phase space of mixed systems consists of regular islands which in two dimensions are dynamically separated from the chaotic sea. Quantum mechanically these phase space regions are connected by dynamical tunneling. We derive a simple formula for the tunneling rates that incorporates the properties of the regular island and the chaotic dynamics. It applies to the case when Plancks constant is a few times smaller than the size of the island, where resonance assisted tunneling can still be neglected. We demonstrate for some kicked systems that it gives excellent agreement with numerically determined tunneling rates. It will be discussed why it is difficult to evaluate the formula in general.

[IA-71] Growth and allocation of resources in Econophysics

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Among the achievements of Econophysics, there are:
- new models for price fluctuations in financial markets;
- new models on the allocation of wealth within interacting agents.

This author has been mainly active in the first field and has started research in the second field. In this paper, an overview of the applications of diffusive and equilibrium models to the economic problem of growth and allocation of resources will be presented.

- Keywords: Econophysics, diffusion, growth, allocation
- Related: http://ideas.repec.org/e/psc89.html

[IB-71] Dynamic model for failures in biological systems: criticality and resonance

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We present a dynamic model for failures in biological organisms, where each cell becomes dead under sufficiently strong stress and is then allowed to be healed with some probability. Revealed is the characteristic time evolution that the system tends to resist the stress longer than the system without healing, followed by sudden breakdown with some fraction of cells surviving. The distributions of the clusters of failed cells and associated power spectra are also examined with regard to the possibility of self-organized criticality. Under periodic stress, the average fraction of intact cells decays stepwise or exhibits oscillating behavior, depending on the stress and healing. The power spectrum at the stress frequency at first increases with the healing parameter, then decreases, which may be called healing resonance. In case thathealing varies periodically with time, the system undergoes a transition from the unhealthy state to the healthy one as the healing frequency increases. This suggests how to adjust the frequency of medical treatment to the optimum.

- Keywords: dynamic model, criticality, resonance

[IA-81] Dissipation in strongly disordered quantum magnets

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The presence of quenched disorder in a quantum mechanical system may have drastic effects in particular close to and at a quantum critical point. The appearance of Griffiths-McCoy singularities, leading to the divergence of various quantities like the susceptibility at zero temperature even far away from a quantum critical point, has received considerable attention recently. This quantum Griffiths behavior is characteristic for quantum phase transitions described by an infinite randomness fixed point (IRFP), which is relevant for many disordered quantum systems. Here we study the effect of a dissipative environment, as for instance present in metals due to the conduction electrons, on such a scenario in a magnetic system with a strong disorder renormalization group scheme. We find that at the coupling of disordered magnet to a dissipative Ohmic bath transforms the sharp quantum transition into a smeared one and produces a crossover from singular quantum-Griffiths behavior to classic Curie behavior at low temperatures.

- Keywords: random magnets, quantum phase transition, Griffiths-McCoy singularities, dissipation
- Related: cond-mat/0511608

[IB-81] Probing chemical communication between neuron-glial cell networks

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I will show calcium imaging data of rat cortical neurons and glial cells grown in co-culture and in microchannel devices, and discuss the ideas and challenges involved in probing the interaction dynamics of these chemically coupled cell networks at both a chemical-cellular and a network scale. Glial cells, which comprise 90% of brain mass, were seen only as mechanical scaffolding and nutrient/waste management support for neurons until recent experiments revealed glial cells contribute to neuronal signaling through chemical interactions at synapses. However, the functional role glia play in the signaling mechanisms of the brain is largely not understood. I will discuss our efforts to quantify spatio-temporal signaling patterns of neuron-glia cell networks, and to understand the functional role of these two cell types in storing functional information in networks.

- Keywords: pattern, neuron, glia, network

[IB-82] Connectivities induced Synchronization in Cortical Neuronal Networks

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Synchronization of cortical neural cultures is studied as a function of the effective network connectivity ($\bar{k}$) in thephenomenon of synchronized firing (SF). The synchronized bursting frequency (f) during SF of the networks is found to be much slower than the characteristic time scale of a neuron and is an increasing function of $\bar{k}$. Although some aspects of the observed SF is similar to the array enhanced synchronization, detailed comparison of measured spike statistics from synchronized and non-synchronized cultures suggests that the nature of synchronization during SF is different from that of the array-enhanced synchronization. Possible mechanisms of SF and the nature of the synchronization are discussed.

- Keywords: neural networks, synchronization

[CA-11] Stabilizing Aggregates in the Dynamics of a Competing Population

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We propose a dynamical model of a competing population, whose agents have a tendency to balance their decisions in time. The model is applicable to financial markets in which the agents trade with finite capital, or other multi-agent systems such as routers in communication networks attempting to transmit multi-class traffic in a fair way. We find phase transitions to oscillatory behavior, explainable by the aggregation of agents into two groups. Each group remains winning over longer time scales called *epochs*. For epochs with long lifetimes, the aggregation of *smart* agents is able to explain the lifetime distribution of epochs to 8 decades of probability. For epochs with short lifetimes, identifying the behavior of the *super-smart*, *super-mediocre* and *super-dump* agents provides a self-consistent description of the lifetime distribution, through an analysis of the historical occurrence of the signals. Our theory is applicable to arbitrary complexity of the strategies adopted by the agents.

Acknowledgement: This work is supported by the Research Grant Council of Hong Kong (HKUST6062/02P and DAG04/05.SC36).

- Keywords: competing population, minority game, dynamical transitions, epochs, agent aggregation
- Related: arXiv:physics/0509185

[CA-12] Equivalence of operator-splitting schemes for the numerical integration of the Langevin equation

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We investigate the equivalence of different operator-splitting schemes for the numerical integration of the Langevin equation. We consider a specific problem, so called the directed percolation process, which can be extended to a wider class of problems. We first give a compact mathematical description of the operator-splitting method and introduce the two typical schemes that will be useful in numerical studies. We show that the two schemes are essentially equivalent through the map that turns out to be an automorphism. An associated equivalent class of operator-splitting integrations is also defined by generalizing the specified equivalence.

- Keywords: Langevin equation, Pokker-Planck equation, Directed percolation, non-commutative algebra

[CB-11] Highly directional emission in stadium-cavity lasers

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The Bunimovich stadium is one of the simplest billiard shapes whose internal particle dynamics becomes strongly chaotic. If one considers an optical cavity incorporating the effect of ray escape at the cavity boundary, a stadium-shaped cavity can generate highly directional emission patterns in spite of the strong chaoticity of the internal ray dynamics, as was demonstrated by Schwefel et al. [J. Opt. Soc. Am. B 21, 923 (2004)]. In this presentation, we report that the lasing solution of a fully nonlinear wave model for stadium lasers exhibits emission directionality in good agreement with the result of the ray-dynamical model. Analyzing the cold-cavity modes relevant for the lasing, we found that all of the high-Q modes have the emission directionality closely corresponding to that of the ray model.

- Keywords: Microcavity lasers, quantum chaos, ray-wave correspondence
- Related: arXiv:physics/0606212

[CB-12] Observation of universal output directionality of single modes with high cavity quality factors in a deformed microcavity

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In our recent experimental investigations of the characteristics of quasi-bound states of a quadrupole-deformed microcavity we could identify five distinct groups of single modes in cavity emission spectra. These modes have much different intracavity mode distributions and consequently their cavity quality factors are different by several orders of magnitude from each other. However, they exhibit almost universal far-field emission patterns, contradicting to their different mode distributions. This universal directionality of the observed modes can be explained by a subtle manifestation of unstable manifolds of classical chaos in the formation of quasi-bound states of wave nature.

- Keywords: quadrupole microcavity, quantum chaos, universal directionality, unstable manifold
- Related: arxiv:physics/0603249

[CA-21] Synchronization transition in scale-free networks : heterogeneously coupled case

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We investigate the synchronization transition from a desynchronized to synchronized state generated by N-coupled oscillators. Those oscillators locate at each vertex of scale-free networks with degree exponent λ. An oscillator of degree k_i is coupled to its neighboring oscillators with asymmetric and degree-dependent coupling in the form of couplingcoeff $k_i^{\eta-1}$. By invoking the mean-field approach, we determine the synchronization transition point J_c, which is zero (finite) when $\eta > \lambda - 2$ ($\eta < \lambda - 2$). We also determine a phase diagram in space of (η, λ) comprising eight different phases. Moreover, we derive the critical exponents associated with the order parameter and describing finite-size scaling behavior in each phase. The synchronization transition is also studied from the perspective of cluster formation of synchronized vertices. The cluster-size distribution and the largest cluster size as a function of system size N are derived for each regime in the phase diagram by using the generating function technique. Our analytic results are confirmed by numerical simulations.

[CA-22] How to enhance network synchronizability

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How to enhance network synchronizability

Synchronization is observed in a variety of natural, social, physical and biological systems, and has found applications in a variety of field including communications, optics, neural networks and geophysics. The large networks of coupled dynamical systems that exhibit synchronized state are subjects of great interest. One of the ultimate goals in studying network synchronization is to understand how the network topology affects the synchronizability. And then, to scheme out effective strategy to enhance or control synchronization. In this presentation, I will give a brief review about the recently proposed approaches to enhance the synchronizability on complex networks.

The outline and main technological papers:

1. Alter the coupling strength, while keep network structure unchanged.

1.1 Use global topological information: M. Chavez, et al., Phys. Rev. Lett. 94, 218701(2005). 1.2 Use the local information only: A. E. Motter, C. Zhou, and J. Kurths, Phys. Rev. E 71, 016116(2005); 1.3 Use local information and unsymmetrical coupling mode: M. Zhao, T. Zhou, and B. -H. Wang, Phys. Rev. E 73, 058102 (2006).

2. Alter the network structure.

1.1 Aim at reduce the heterogeneity of degree distribution: M. Zhao, T. Zhou, B. -H. Wang, and W. -X. Wang, Phys. Rev. E 72, 057102(2005). 1.2 Aim at reduce the average distance: T. Zhou, M. Zhao, and B. -H. Wang, Phys. Rev. E 73, 037101(2006).

3. Use global optimal algorithm.

3.1 For homogeneous networks: L. Donetti, P. I. Huitado, and M. A. Munoz, Phys. Rev. Lett. 95, 188701(2005). 3.2 For Heterogenous networks: B. Wang, H. -W. Tang, T. Zhou, and Z. -L. Xiu, arXiv: cond-mat/0512079(2005).

- Keywords: complex networks; synchronizability; enhancement

[CA-23] Opinion Dynamics on Clustered Networks

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We investigate the opinion dynamics on various networks. The real-world networks have stylized features such as power-law distribution of degree induced by preferential attachment, small-world behaviors, and high clustering. We introduce a simple opinion diffusion model including the effect of high clustering. This model shows textitde facto standard and textitlock-in effect can be explained from a network perspective. Also, it shows the high clustering makes the different features of opinion diffusion altough the clustering coefficients and the average path lengths of those networks are similar.

- Keywords: opinion dynamics high clustering scale-free network small-world network

[CB-21] Synchronization and noise controlled firig patterns in potassium driven neural networks

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Using a relatively simple model we examine how variations of the extracellular potassium concentration can give rise to synchronization of two nearby pacemaker cells. With the volume of the extracellular space and the rate of potassium diffusion as control parameters, the dual nature of this resource-mediated coupling is found to be responsible for the coexistence of competing patterns in-phase and anti-phase synchronization between identical cells. Cell heterogeneity produces significant modifications of the dynamical regimes on control parameter plane. By comparison with convertional gap junctional coupling, potassium signaling gives rise to considerable changes of the cellular response to external stimuli. We also investigate how noise input to small ensembles of neurons communicating via changes of the extracellular potassium concentration can influence the firing patterns. Using the noise intensity and the volume of the extracellular space as control parameters, we show that potassium induced depolarization underlies the formation of noise-induced patterns such as delayed firing or triggered synchronous response that are associated with new time scales in the distribution of interspike intervals.

- Keywords: neural ensembles, synchronization, noise-induced dynamics, extracellular potassium
- Related: 1) D.Postnov, L.Ryazanova, O.Sosnovtseva, E.Mosekilde NEURAL SYNCHRONIZATION VIA POTASSIUM SIGNALING, International Journal of Neural Systems (2006), in press
2) D.Postnov, L.Ryazanova, O.Sosnovtseva, E.Mosekilde NOISE INDUCED FIRING PATTERNS IN

[CB-22] Transition from Weak to Strong Coherence Resonance in Coupled Type-I Neurons

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We study the dynamical response to noise in globally coupled Morris-Lecar (ML) neurons with type-I excitability. For the single case, a subthreshold type-I ML neuron exhibits a maximal correlation without any spectral coherence at some optimal noise intensity (i.e. occurrence of maximal correlation without any appearance of peaks in the output power spectrum). This kind of "weak" coherence resonance (CR) is in contrast to the "strong" CR (i.e., occurrence of maximal correlation along with the spectral CR) occurring in the type-II excitable neuron. For the case of excitatory coupling, synaptic current injected into each type-I ML neuron may be temporally coherent due to spiking synchronization. Consequently, a transition from weak to strong CR occurs through appearance of peaks in the local output power spectrum. This array-enhanced transition is also confirmed in the coupled system consisting of the canonical type-I theta neurons. On the other hand, no array-enhanced effect occurs in the case of inhibitory coupling because no spiking synchronization occurs.

- Keywords: Coupled Neurons, Coherence Resonance, Spiking Synchronization

[CB-23] Dynamically perturbed n-vector model

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We investigate an n-vector model which is away from equilibrium and subjected to non-equilibrium perturbations that are spacially anisotropic. The Renormalization Group analysis reveals many interesting features. For example, in some domain in the coupling constant space these anisotropic perturbations, though retain the equilibrium behaviour in the long-distance and large-time limit, make the system crossover to lower symmetric equilibrium fixed points. While in some other domain the asymptotic behaviour of the system is far from equilibrium. In this case, this drastic difference might have been induced due to the emergence of conserved dynamics on the critical surface of this domain.

[CA-31] Price of Anarchy in Complex Networks

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We present an optimization problem of network flow in decentralized systems like data transportation, traffic, population, work flow, etc., where their latency cost functions are congestion-dependent. The flow pattern can be intentionally regulated by a global rule or may emerge by individual selfish strategies, depending on the type of system. The latter is known for settling at Nash equilibrium in a game-theory context, which mostly results in worse than a global optimum in optimization problems. This gap has been coined as "The price of anarchy", representing the worst inefficiency of selfishness. Nevertheless, this price can be lowered, according to Braess's paradox, by removal of edges in a given system that intend to reduce a global optimum, regardless of Nash equilibrium. Accordingly, this paper investigates tendencies of the price of anarchy in a real system, a simplified Boston road network, and our work suggests a potential application of new methods to optimize flow in a decentralized system, which is closer to reality in diverse systems.

- Keywords: Complex Networks, Price of Anarchy, Nash Equilibrium

[CA-32] Local symmetries in complex networks

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Symmetry – invariance to certain transformations – is a fundamental concept in many branches of physics. We propose ways to measure symmetric properties of vertices in networks. To be stable to the randomness inherent in many complex networks we consider measures that are continuous rather than dichotomous. The main operator we suggest is permutations of the paths of length l leading out from a vertex. If these paths are more similar (in some sense) than expected the vertex is a local center of symmetry in networks. We discuss different precise definitions based on this idea and evaluate them on real and model networks.

- Keywords: complex networks, grapth theory, symmetry
- Related: http://arxiv.org/abs/physics/0605029 (the talk will be on an extension/generalization of this work)

[CB-31] Understanding synchronization induced by "common noise"

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Noise-induced synchronization refers to the phenomenon where two uncoupled, independent nonlinear oscillators can achieve synchronization through a "common" noisy forcing. Here, "common" means identical. However, "common noise" is a construct which does not exist in practice. Noise by nature is unique and two noise signals cannot be exactly the same. How to justify and understand this central concept in noise-induced synchronization? What is the relation between noise-induced synchronization and the usual chaotic synchronization? Here we argue and demonstrate that noise-induced synchronization is closely related to generalized synchronization as characterized by the emergence of a functional relation between distinct dynamical systems through mutual interaction. We show that the same mechanism applies to the phenomenon of noise-induced (or chaos-induced) phase synchronization.

- Keywords: noise-induced synchronization generalized chaos synchronization

[CA-41] Study of Nonlinear Dynamics and Collective Effects with Cold Atoms

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Magneto-optical trap (MOT) has been one of the most widely used tools for atomic and optical physics. Because of its simplicity, accessibility, versatility, and controllability, it will continue to serve as a simple atomic model system for various fields of research. In this talk, we discuss some application of the simple MOT to study of interdisciplinary nature in statistical physics and condensed matter physics, such as nonlinear bifurcation, collective phase transition, mesoscopic physics, cooperative instability, plasma physics, and nano physics, etc.

[CB-41] Interacting particle systems in complex networks

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We study stationary and transient behaviors of interacting particle systems on complex networks. Complex networks are characterized with an inhomogeneous structure with a broad connectivity distribution. Due to the inhomogeneous structure the particle systems on complex networks display interesting behaviors. We present those behaviors in a random walk model, a pair-annihilation process, and a zero-range process studied on complex networks.

[CB-42] Finite-Size Scaling in Complex Networks

Meesoon Ha, Hyunsuk Hong, and Hyunggyu Park

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Recently, Castellano and Pastor-Satorras [PRL **96**, 038701 (2006)] utilized the finite size scaling (FSS) theory to analyze simulation data for the contact process (CP) on scale-free networks (SFNs) and claimed that its absorbing critical behavior is not consistent with the mean-field (MF) prediction. Furthermore, they pointed out large density fluctuations at highly connected vertices as a possible origin for non-MF critical behavior. We propose a scaling theory for relative density fluctuations in the spirit of the MF theory, which turns out to explain simulation data perfectly well. We also measure the value of the critical density decay exponent, which agrees well with the MF prediction. Our results strongly support that the CP on SFNs still exhibits a MF-type critical behavior. Based on a hyperscaling-type argument, we conjecture the value of the FSS exponents for the Ising model and the suscpetible-infected-susceptible model besides the CP, all of which are numerically confirmed.

- Keywords: Finite-Size Scaling, Scale-Free Networks
- Related: cond-mat/0603787

[CA-51] Growth model of Neuronal Network in vitro

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We present a detailed analysis and theoretical growth models to account for recent experimental data on the growth of cortical neuronal networks *in vitro* [Phys. Rev. Lett. **93**, 088101]. The experimentally observed synchronized firing frequency of a well connected neuronal network is shown to be proportional to the mean network connectivity. The growth of the network is consistent with the model of an early enhanced growth of connection, but followed by a retarded growth once the synchronized cluster is formed. Microscopic models with dominant excluded volume interactions are consistent with the observed exponential decay of the mean connection probability as a function of the mean network connectivity. The biological implications of the growth model are also discussed.

[CB-51] Microwave acoustoelectric soliton in piezoelectric semiconductors

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Four decades ago, low-frequency current oscillations were observed in piezoelectric semiconductors submitted to a moderate static electric field (>700V/cm). This effect was characterized by a high field (3500V/cm) domain, building up over a low field (60V/cm) background and moving throughout the sample at sound velocity. This phenomenon was never explained because the most interesting feature, i.e. a large amplitude (5000V/cm peak to peak) microwave field carried along within the solitary domain, has been overlooked in the then used detection procedure. Negative differential conductivity stemming from piezoelectric coupling will be shown to give rise to a mm-wide, high-amplitude acoustoelectric microwave-packet moving at sound velocity. Because the electric permitivity is inferred to be renormalized to zero, the properties of this solution will be shown to be shaped by the nonlinear piezoelectric interaction. The initial transient regime turns out to be strongly correlated with the observed frequency shift of maximum Brillouin scattering. Possible implementation of a powerful and versatile acoustoelectric generator is mentioned.

- Keywords: nonlinear and acoustoelectric effects, piezoelectricity induced instabilities
- Related: szeftel et al., Europhys.Lett., 73, 752 (2006)

[CB-52] Effective phonons in anharmonic lattices: anomalous vs normal heat conduction

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Heat conduction in one dimensional system has attracted increasing attention in last decade. Many papers have been published, however, a unified theory is still lacking in explaining the existing anomalous heat conduction in the Fermi-Pasta-Ulam like models and normal heat conduction in the Frenkel Kontoroval and the f4 model. In this talk, I report our recent study (both numerically and analytically) on this problem by using an effective phonon theory. It is found that every effective phonon mode oscillates quasi-periodically. By weighting the power spectrum of the total heat flux in the Debye formula, we obtain a unified formalism that can explain anomalous heat conduction in momentum conserved lattices without on-site potential and normal heat conduction in lattices with on-site potential. Our results agree very well with numerical ones for existing models such as the Fermi-Pasta-Ulam model, the Frenkel-Kontorova model and the f4 model etc.

- Related: N-B Li, P.-Q Tong, and B Li, Europhys. Lett (2006) (in press)

[CB-53] Dynamical mode locking in commensurate structures with an asymmetric deformable substrate potential

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The overdamped dynamics in the commensurate structures of the one-dimensional Frenkel-Kontorova model subjected to a parametrized deformable periodic substrate potential and driven by a periodic force is examined. It was found that when the shape of the substrate potential starts to deviate from the standard one, new subharmonic steps appear in the response function even in the structures with an integer value of average interparticle distance while the critical depining force can even decrease for some values of system parameters. These novel phenomena could be particularly relevant for the charge-density wave systems, vortex lattices, and systems of Josephson-junction arrays.

- Keywords: ac driven Frenkel Kontorova model, dynamical mode locking
- Related: B. Hu and J. Tekic, PRE 72, 056602 (2005)

[CA-61] Asymmetric coupling from visual evoked theta to ongoing alpha induces the alpha phase resetting

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We perform phase analysis of the alpha (8-13Hz) and theta (4-7Hz) rhythmic components of the single-trial electroencephalograms(EEGs), which comprise the most dominant contributions to the event related potentials(ERPs). The oscillatory ERP patterns of two components are well described by the phase resetting and the inter-trial phase coherency. A method for the estimation of the nonlinear dynamic dependency between two components is proposed. According to the method, the coupling is asymmetric with the coupling from the theta to the alpha rhythms stronger than the reversed one.

- Keywords: EEG, theta rhythm, alpha rhythm, phase analysis, asymmetric coupling, phase resetting

[CA-62] Theoretical approach to neural network regulations for spike-based Hebbian learning

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Synaptic plasticity rules depending on precise spike timings are attracting much interest in connection with more realistic neural models and novel learning mechanisms. It is more or less understood how neural networks would regulate depending on the types of spike-timing dependent plasticity (STDP) window. Nevertheless, a manipulation of learning processes under the STDP rules remains as a difficult problem. In this paper, we suggest a theoretical method to calculate the spatio-temporal correlation of neural firings more effectually. This makes it possible to anticipate in detail the modification of neural circuits depending on STDP rules, external activities, random noises, network structures, and so on. Our analysis, based on path integrals and fluctuating fields, are quite general which can be applied to other physical systems. Our method may provide a theoretical foundation for understanding neuro-information processing in more realistic neural models.

- Keywords: Neural network learning Spike-timing dependent plasticity Statistical field theory

[CB-61] Analysis of the Nodal Structure for a Nonintegrable Two-Dimensional Quartic Oscillator

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We investigate the transition from integrable to chaotic dynamics in the quantum mechanical wave functions from the point of view of the nodal structure by employing a two dimensional quartic oscillator. We find that the number of nodal domains is drastically reduced as the dynamics of the system changes from integrable to nonintegrable, and then gradually increases as the system becomes chaotic. The number of nodal intersections with the classical boundary as a function of the level number shows a characteristic dependence on the dynamics of the system, too. We also calculate the area distribution of nodal domains and study the emergence of the power law behavior with the Fisher exponent in the chaotic limit.

- Keywords: quantum chaos, nodal domain
- Related: H. Aiba and T. Suzuki, Phys.Rev. E72 (2005) 066214. (nlin.CD/0508019)

[CB-62] Oscillations in photoionization of two-electron atoms

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Quantum calculation of oscillations in photoionization of 1-dimensional collinear helium atom is reported for the final energy interval $[I_{14}, I_{52}]$. The Fourier transform of the oscillating part reveals the role of the orbits which begin and end at triple collision, i.e. the returning orbits of triple collision. A scaling law for the oscillations, which is regarded as the below-threshold partner of the Wannier's law, is found for the first time. And a simple semiclassical method provides an explanation of the origin of the scaling law.

- Keywords: oscillations in photoionization, collinear helium, triple collision, Wannier's law

[CA-71] Phase distribution and phase correlation of financial time series

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The scaling, phase distribution, and phase correlation of financial time series are investigated based on the Dow Jones Industry Average and NASDAQ 10-min intraday data for a period from 1 Aug. 1997 to 31 Dec. 2003. The returns of the two indices are shown to have nice scaling behaviors and belong to stable distributions according to the criterion of Lévy's α stable distribution condition. An approach catching characteristic features of financial time series based on the concept of instantaneous phase is further proposed to study the phase distribution and correlation. Analysis of the phase distribution concludes that return time series fall into a class which is different from other nonstationary time series. The correlation between returns of the two indices probed by the distribution of phase difference indicates that there was a remarkable change of trading activities after the event of the 9/11 attack, and this change persisted in later trading activities.

- Keywords: phase correlation; financial time sereis; scaling analysis
- Related: Phys. Rev. E 73, 016118 (2006).

[CA-72] Multiscaling behaviors of the Korean stock market

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We consider the scaling and multiscaling behaviors of the Korean stock-market index. We consider the return and absolute return of the Korean stock index KOSPI. We observed the scaling behaviors in the tail parts of the probability distribution of the return, the autocorrelation function of the absolute return, and the waiting time distribution of the absolute return. The generalized q-th order height-height correlation functions show multiscaling properties. There are two scaling regime, with a crossover time t_c =40min. We smooth the index through convolution with a Gaussian function. After the convolution we observed that the multifractality disappeared in the short time regime $t < t_c$, but remains in the long-time scaling regime $t > t_c$. The multiscaling in the long-time regime appears to be due to intrinsic trading properties of the stock-market.

- Keywords: Multiscaling, Multifractal, stock market, power law

[CA-73] Persistence in Random Bond Ising Models of a Socio-econo Dynamics in High Dimensions and Financial Markets

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We study the persistence phenomenon in a socio-econo dynamics model using computer simulations at a finite temperature on hypercubic lattices in dimensions up to 5. The model includes a social local field which contains magnetization at time t. The nearest neighbour quenched interactions are drawn from a binary distribution which is a function of the bond concentration. We determine the decay of the persistence probability in the model. We discuss our results, which indicate the existence of *blocking*, and the implications in the social and economic context.

Persistence is also studied in a financial context by mapping the time evolution of the values of the shares quoted on the London Financial Times Stock Exchange 100 index (FTSE 100) onto Ising spins. Historical data over a 10-year period is analysed. By following the time dependence of the spins, we find evidence for power law decay of the proportion of shares that remain either above or below their "starting" values. As a result, we estimate a persistence exponent for the underlying financial market to be approximately 0.5. The persistence behaviour of the log-returns is also discussed.

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[4] S Jain and P Buckley, European Physical Journal B **50**, 133 (2006)

- Keywords: Econophysics, non-equilibrium dynamics, Ising models, persistence
- Related: S Jain and P Buckley, European Physical Journal B50, 133-136 (2006)

[CA-74] Two-phase herd behavior in financial markets

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We study the two-phase behavior for tick data of Korean treasury bond (KTB) futures in financial markets. All the statistics attributed to KTB503 such as the trade frequency, volume, and price are analyzed. The statistical quantities related to the Langevin-typed stochastic process is derived by using the Fokker-Planck equation. It is really showed what effect the correlation between them can make on the two-phase behavior. From our result, we remark the bridge between the temporal correlation in the herd model and non-markovian property of stochastic process.

- Keywords: Two-phase behavior, KTB, Herd model

[CB-71] Spatial synchronizatin and extinction of species

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Extinction of the species on a global scale is a puzzle due to the ‘rescue effect’. According to the rescue effect, a species under an external threat may survive in some isolated locations and then can lead to the revival of the species. Spatial synchronization can prevent rescue effect. We show using a general model with quadratic saturation term that under a common external forcing, the species first undergoes spatial synchronization and then extinction. This is because the saturation term in the population dynamics reduces the synchronization time scale but not the extinction time scale. Thus the populations do not survive in isolated locations and extinction takes place almost simultaneously in all the locations. The effect can be observed even when the external forcing acts only on some locations provided the dynamics contains a synchronizing term. Absence of the quadratic saturation term can help the species to avoid extinction.

- Keywords: synchronization, extinction of species

[CB-72] Entrainment transition in coupled random frequency oscillators

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We investigate the frequency entrainment in a large population of interacting limit-cycle oscillators with random frequencies. The Edwards-Anderson order parameter and the related spin-glass susceptibility are examined, and the critical behavior is analyzed near the transition. The model of globally coupled limit-cycle oscillators is re-examined and is shown to exhibit an unusual sample-dependent size effect near the entrainment transition. Extensive simulations have also been performed on the locally coupled oscillators, where the critical exponents are obtained.

- Keywords: entrainment transition, limit-cycle oscillators, EA order parameter

[CB-73] A Unifying Hybrid Attachment Model and Its Effects of Hybrid Ratio on Topological and Dynamical Properties

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Based on the hybrid preferential model proposed by Fang and Liang [1], we further propose a unifying hybrid attachment model (UHAM) for both unweighted and weighted networks in this talk, Comparing of the UHAM with main existing models, such as the BA [2], BBV [3] and TDE [4] models, the UHAM has smallest average path length L and biggest average clustering coefficient C, which are much better and closer to real-world networks. The effects of different hybrid ratio d/r of random to deterministic links and their hybrid attachment order (HAO) on complex network are investigated. It is found that the hybrid ratio d/r is a most key control parameter which has very important effecting on topological properties of complex networks, but the no matter how HAO is, there is no effect on them basically. As the hybrid ratio increases, the average clustering coefficient is increased, the average path length and the assortative coefficient, which is associated with dynamical synchronizability, are decreased. The UHAM yields a nontrivial time evolution of topological properties and scale-free behavior for the degree, weight and strength distributions, as well as the exponent γ of various power-law in the UHAM is sensitive to the ratio d/r; there exists a threshold at the ratio of d/r = 1/1, beyond which the exponent value γ increases rapidly and will tend to infinity when the $r = 0$, the power-law disappears in this extreme case. All findings for the UHAM are held not only for the unweighted networks but also for the weighted networks. These findings imply that the UHAM is a series of universal properties for many complex networks. The ideas and method of the UHAM provide a wide variety of scale-free, small-world properties, and dynamical transition features. All the results show that the random preferential attachment is the main mechanism for generating the scale-free feature but the deterministic attachment can play an important construction role in generating a power-law without heavy random tail and in enhancing the "rich gets richer" phenomenon, and that reveals a unifying coherent mechanism which is consistent with real-world networks. The comparisons with existing three kinds of network models demonstrate that the UHAM is much closer to real-world complex networks not only for unweighted networks but also for the weighted networks. Therefore, the UHAM can be extended to a large class of complex networks, and may have great potential for applications in both theory and practice.

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- Keywords: Unifying hybrid attachment model, scale-free, small world, weighted networks

[CA-81] Quantum phase transition and finite-size scaling

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We study the quantum phase transition in the one-dimensional quantum Ising model at zero temperature. As the strength g of the transverse field is changed, the system undergoes a phase transition from ordered to disordered phases, characterized by the spontaneous magnetization in the z-direction. We apply the standard technique of the finite-size scaling in statistical mechanics to detect the nature of the quantum phase transition in the system.

- Keywords: quantum phase transition quantum Ising model finite-size scaling

[CA-82] Pumps operating at the boundary between classical and quantum world

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I present a new mechanism to generate a dc current of particles at zero bias based on a noble interplay between coherence and decoherence. I will show that a dc current arises if the transport process in one direction is maintained coherent while the process in the opposite direction is incoherent. I will provide possible implementations of the idea using an atomic Michelson interferometer and a ring interferometer. The relationship to the second law of thermodynamics and the detailed balance will be discussed.

- Keywords: decoherence; lasing without inversion; detailed balance; quantum thermodynamics;
- Related: Phys. Rev. Lett. 95, 226802 (2005)

[PB-01] Pharmacological effects of a novel Na+ channel agonist, Dimethyl Lithospermate B on the wave dynamics of cultured cardiac tissue

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It has recently been proposed that Dimethyl Lithospermate B (dmLSB), which is an extract of Danshen popularly used in traditional Chinese medicine, can be used as an antiarrhythmic agent in the setting of Brugada syndrome for it slows the inactivation of Na+ current thus, prolonging the action potential duration (APD) and inhibiting the onset of fibrillation. Unlike other voltage-gated K+ channel blockers that have several major side effects as an antiarrhythmic pharmacological agent, dmLSB is also known for its negligible electrophysiological side effect other than prolonging APD. Past pharmacological studies regarding dmLSB are mostly limited to the electrophysiological property of single cardiac cells. In this work, we have examined the pharmacological effects of dmLSB on cardiac wave dynamics in cultured tissue of rat ventricle myocytes. Non-invasive phase contrast macroscope is used to visualize the contractile waves, and the effects of dmLSB on the properties of the cardiac waves are quantified by measuring changes in 1) dispersion relation of cardiac wave train generated by a local periodic electric field stimulation and 2) characteristic properties of cardiac reentries. In addition, we have conducted a series of computer simulations on a realistic model and compared the results with the experimental ones.

- Keywords: dmLSB;antiarrhythmic agent;dispersion relation

[PB-02] Bursting of neurons induced by inhibitory mechanism

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We present a mean field model of the neural network that combines a Fitz-Hugh Nagumo (FHN) model with an additional dynamic variable. This new variable is slower than those in the FHN model. It enables the neuron firing to be inhibited and generates inter-spike intervals (ISI) with long time scales resulting in bursting. This phenomenon is also observed in cortical neuronal cultures where the bursting frequency is found to be much slower than the characteristic time scale of a neuron. By comparison, the additional variable may be regarded as a glial field with inhibitory roles and some properties of our neuron model are discussed. In particular, bursting occurs when the mean coordination number of a neuron with gila field exceeds a threshold value. Furthermore, in the presence of noise, the ISI distribution displays complex and nontrivial patterns.

[PB-03] Long Range Correlation and Possible Electron Conduction Through DNA Sequences

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The possible conductivity behavior of an electron via a DNA sequence can be studied under the framework of Anderson tight-binding model. Pedro Carpena et al. using this model have demonstrated that for a simple dual random sequence without long range correlation, electronic wave functions are strongly localized. Electron conduction phenomenon is therefore not anticipated. However if a sequence is long range correlated electronic wave functions could become somewhat extended. This feature gives possible electronic conductivity behavior through a long range correlated random sequence. We use the same model to explore possible electron conductivity mechanism in the Saccharomyces Cerevisiae DNA sequences. These sequences are long range correlated and possible electronic conductivity is anticipated. Our results show quantitatively that electronic wave functions do somewhat more extend than in the case of non-correlated random sequences. We also show some statistical characteristic quantities which are essentially different when we compare sequences with and without long-range correlations.

[PB-04] Operon-like motif structure in transcriptional regulation of Saccharomyces cerevisiae

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Recently there are several studies focused on the transcriptional regulation of gene expression program in Saccharomyces cerevissiae. Although important differences exist between the regulatory system of prokaryotes and eukaryotes, it has been suggested that multi-gene regulation or like operon structure may be also exist in eukaryotes. For the exploration of this notion, in this study we have investigated the regulation of gene expression by 106 transcription factors in Saccharomyces cerevissiae based on genome wide location analysis data of Lee at al. (Science vol. 298, 2002). By using computational method we have analyzed the position of genes, regulated by 106 transcription factors, on 16 chromosomes and the results showed that the chromosome-wide distribution of regulated genes by 106 transcription factors is very uniform over 16 chromosomes. As we investigate the genome-wide distribution, unexpectedly, we have identified the appearance of 2-, 3-, 4-, 5- and 6-gene motif structure, called "Operon-like motif structure", in which several genes sequentially regulated by the same transcription factor. To understand the functional role of the operon-like motif structure we investigated gene expression profile of these motifs under 314 experimental conditions. The results of the analysis gene expression profile showed high correlation among genes in motif compared to random pairs, especially under specific experimental conditions. Our results provided the evidence for the existent of operon-like motif structure in Saccharomyces cerevissiae.

- Keywords: operon, Saccharomyces cerevissiae,

[PB-05] Synchronization during the Growth Myocardial Cultures

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The synchronization phenomena during the growth of myocardial cultures are studied by video imaging analysis. Cardiac cells are obtained from the ventricle of postnatal (3 days old) rats. Morphological and contraction changes of the cultured cells are monitored. Some cells in the cultures are observed to beat 8 hours after plating and all the cells in the cultures are found to beat 24 hours after plating. No synchronization of the beatings of the cells are observed until 72 after plating when cells are seen to form clusters and beat synchronously within the growing cluster. The frequency of this synchronized beating is found to be a decreasing function of the plating density. Synchronization among different clusters is in the form of a travelling wave.

- Keywords: primary culture,synchronization,cultures

[PB-06] Dynamics in growing networks of cortical neurons

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In the early stage of development, (spike) firing patterns of biological neural network change dramatically as the complexity and the strength of cell-to-cell connectivity increase rapidly in the growing network. Using a model in vitro system, a primary culture of rat cortical neurons grown on MEAP (multi-electrode array plate), we have investigated this interesting dynamic process spanning over a few weeks. The systems spontaneous firing activity is typically a complex mixture of single spikes and spatiotemporally synchronized bursting events. The frequency of both events increases as the culture becomes more mature over days. We find that in general the signal transduction sequence and time delay of single spikes taken at different channels are different from those of bursts. This interesting property in turn suggests that the neuronal circuit which is responsible for the generation of single spikes is different from that for the burst generation. We have also constructed two-dimensional correlation maps of hierarchical clustering based on the values of linear pair cross-correlation. These maps are found to be very useful in identifying hidden spatiotemporal structures.

- Keywords: MEA, neuronal network, cortical neuron, visual cortex

[PB-07] Puzzling Origin of the Circadian Oscillation of Cytosolic Calcium Level in Rat Suprachiasmatic Nucleus

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The circadian rhythm of the action potential (AP) firing rate in the suprachiasmatic nucleus (SCN) is a well-known phenomenon. Also known is the slow circadian oscillation of cytosolic calcium level. More recently, it is found that some cells in SCN organotypic cultures do support large amplitude calcium spikes. As an attempt to identify the role of these calcium activities related to the circadian oscillation, we have measured the cytosolic calcium level and the membrane potentials simultaneously using a calcium dye Fluo-4 along with a whole cell patch setup. We find that the spontaneously arising calcium spikes are primarily produced by glial cells, whereas SCN neurons exhibit mostly small amplitude calcium fluctuations that are strongly correlated with the firing rate of action potentials in a short time (orders of seconds) scale. Interestingly, however, the event frequency of calcium spikes seems to have a circadian rhythm, similar to that of action potentials. Thus our experimental results suggest that there exist at least two different calcium kinetics operating at two rather different time scales. Knowing that there exists a phase delay of approximately four hours between the slow circadian oscillation of cytosolic calcium level and that of action potential firings, the origin of the slow calcium circadian oscillation is still a puzzle.

- Keywords: calcium spikes, circadian rhythm, action potential(AP), suprachiasmatic nucleus (SCN), calcium dynamics

[PB-08] Ca2+ dynamics in pancreatic duct epithelial Cell

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Recently intensive studies have been done to explain biological systems quantitatively with mathematical models. In these approaches, it is an important problem to verify the physiologically reasonable parameters in the model. In this study, we measure and simulate the Ca2+ dynamics in pancreatic duct epithelial cells (PDEC) in perturbed conditions to prove the parameters in our model. Using the antagonists, we block the functions of the specific proteins such as the sarcoplasmic endoplasmic reticulum calcium ATPase (SERCA), plasma membrane calcium ATPase (PMCA), calcium release-activated current channel (CRAC), phospholipase C (PLC) and the Na/Ca exchanger (NCX) in the experiments. These perturbations are simulated by changing of parameters corresponding to the functions of the proteins. Both results of the experiments and the simulations show quiet similar pattern changes at the oscillatory condition with our parameters. They also show similar changes of the time constants of the Ca2+ clearance at high concentration of agonist. The concentration of the cytosolic inositol-1,4,5-trisphosphate (Ins(1,4,5)P3) is included in our model as a dynamic variables. Our simulation results show the in-phase dynamics between the Ca2+ concentration and the Ins(1,4,5)P3 concentration in the perturbed conditions as well as in normal conditions. This can be the evidence that the intracellular Ins(1,4,5)P3 plays an important role in the intracellular Ca2+ dynamics.

[PB-09] Geometric Resonance in the Refractory-Activation Oscillator Model for the Cross-bridge Formation in the Actomyosin System

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Contractile motion of muscle fibres arises from the microscopic process of mechanochemical energy transduction through the transient cross-bridge formation between actin and myosin filaments. It is indicated that a large number of cross-bridges work cooperatively and create the coherent macro-motion of filament. Then it is worth noticing that the macro-motion induces the feedback effect to the energy transformation and regulates the micro-dynamics of the internal degrees of freedom in each cross-bridge. In general, such kind of the feedback loop between micro- and macro- dynamics plays a significant role in active element system in order to organize global functions as a whole. Here we propose a theoretical model of the cross-bridge formation process and simulate the complex behaviors which link the microscopic level and macroscopic one. The basic assumptions of our model are followings: (1) the cross-bridge formation occurs within active regions distributed periodically on the actin filament; (2) the state of cross-bridge is inactive for a certain refractory period; (3) the force production of each cross-bridge varies with the relative velocity between each filament. This is called the Refractory-Activation Oscillator Model. In the previous studies, it is showed that the Hills relation can be reproduced and realized underlying two kinds of cooperative phenomena, i.e. coherent cooperativity and turbulent one. In the present paper, we analyze the effect of the geometrical parameters in our model. It is especially emphasized that when we change the modulated period-ratio between two filaments, remarkable resonance appears near simple rational numbers. The relationship between the resonance and the period-ratio is analyzed in terms of the Farey sequences. Moreover, we will discuss some anomalous scaling laws of the total force fluctuation, and the finite size effect in detail.

- Keywords: resonance, Refractory-Activation Oscillator Model, muscle contraction, cross-bridge, Farey sequences, finite size effect

[PB-10] Phase Specific Activated Modules from Protein Interaction Network of Yeast Cell Cycle

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We have constructed cell cycle-related protein interaction network of Saccharomyces cerevisiae from MIPS database. The network shows character of scale free and hierarchical networks. Protein interaction database obtained from a yeast two hybrid screen and a composite data set includes high random false positives. To filter the false positives, we employed cellular localization and then reconstructed cell cycle network, in which preserves scale free and hierarchical organization and displays inherent modularity of protein clusters. Interestingly, several modules, denoted phase specific activated modules, active in response to phase of cell cycle. From the derived modules, we predicted and tentative functions for unaanotated proteins and estimated some proteins activated in a periodic manner coincident with the cell cycle.

- Keywords: Module, Cell cycle network

[PB-11] Emergence of Chaotic Itinerancy in Simple Ecological System

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Chaotic itinerancy is a universal dynamical concept that describes itinerant motion among many different ordered states through chaotic transition in dynamical systems. Unlike the expectation of the prevalence of chaotic itinerancy in high-dimensional systems, we identified the chaotic itinerant behavior from a relatively simple ecological system, which consists only of two coupled consumer-resource pairs. The system exhibits the chaotic bursting activity in which the explosion and the shrink of the population alternate indefinitely, while the explosion of one pair co-occurs with the shrink of the other pair. We analyzed successfully the bursting activity in the framework of chaotic itinerancy, and found that large duration times of bursts tend to cluster in time, allowing the effective burst prognosis. We also investigated the control schemes on the bursting activity, thus demonstrated that invoking the competitive rise of the consumer in one pair can even elongate the burst of the other pair rather than shorten it.

- Keywords: chaotic itinerancy consumer-resource system bursting activity

[PB-12] Investigation on the mechanical properties of macrophages

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During immune responses, macrophages play important roles in antigen presentation by engulfing pathogenic microorganisms and cell debris. Since their functions highly depend on migrational abilities, here we have investigated the mechanical properties of macrophages by manipulating them with a flexible pipette. First, we have studied the response of macrophages to external force applied by a flexible pipette and the rate of movement upon physical or chemical stimuli. In order to obtain a quantitative picture of their mechanical natures, we need to calibrate the forces applied to a single macrophage. Second, we have examined the effect of the contact surface of the pipette on the response of macrophages. Chemical, biological, and structural characters of the tip of the pipette appear to be important factors in their interaction with external objects. Through these studies, we have acquired a better understanding on mechanics of macrophages.

- Keywords: macrophage mechanics

[PB-13] Neuron-Glia Interaction in Cultured Network of Rat Cortex

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Understanding of the role of glia as regulatory elements in the neuronal activity besides of providing neurons with stable environment is one of the most important issues on the central nervous system (CNS). While the fundamental attribute of neuron is the action potentials, glial cell can display "Ca^{2+} spikes." As a step towards understanding their interplay, we have prepared a low density neuronal culture on the top of confluent glial pre-culture to investigate how macroscopic calcium waves generated by glial network influence the overall dynamics of neural network. As their activities sensitively depend on the ionic conditions of extracellular matrix, we have systematically varied the concentrations of extracelluar Ca^{2+} and Mg^{2+} and quantified any change in the spatio-temporal dynamics of cytosolic calcium levels in this heterogeneous cell population. As well, we have carried out pharmacological studies administrating various channel or receptor agonists/antagonists in order to understand the nature of neuron-glia interactions. The experimental results will be presented.

- Keywords: Neuron, glia, action potential, calcium wave,

[PB-14] The reconstruction of the qualia space based on multi-channel electroencephalograms and the dynamic properties of the consciousness trajectory.

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The connectionists have suggested a theory about what consciousness is and how it can be measured. According to the theory, consciousness corresponds to the capacity of a system to integrate information and the quality of consciousness is determined by the informational relationships between the elements. A conscious state at a given time consists of various local brain functions. Such local brain functions and their global integration can construct a whole conscious state at a given time. We hypothesize that a local brain function corresponds to a causally independent sub-cluster of EEG channels and a global integration of the local brain functions corresponds to a point in the qualia space, whose axes are consisted of all causally independent sub-clusters of EEG channels. In this paper, we introduce the method of reconstructing the qualia space with the multi-channel EEGs, in which the trajectory reflects the time evolution of the mental state. And in the investigation of the dynamic property of the mental state, we found that it shows a fractal property.

- Keywords: Qualia Space, EEG, Consciousness, Fractal, Dynamics

[PC-01] Fractality in Weighted Networks

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Recently, much studies on complex networks have focused on the fractality of the networks. In this work, we present a modified method for the fractal measure of complex networks in order to measure fractals of weighted networks. The complex multivariate and multi-channel data including KOSPI, S&P 500, and EEG signals are transformed into weighted networks and their fractal properties are measured. The fractality of the weighted networks are shown to be equivalent to that of the corresponding minimum spanning trees (MSTs).

- Keywords: Fractal, Weighted Network

[PC-02] Self-organized Criticality and Scale-free Properties in Emergent Functional Neural Networks

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Recent studies on complex systems have shown that the synchronization of oscillators including neuronal ones is faster, stronger, and more efficient in small-world networks than in regular or random networks. We show that the functional structures in the brain can be self-organized to both *small-world* and *scale-free* networks by synaptic re-organization through the spike timing dependent synaptic plasticity (STDP) instead of conventional Hebbian learning rules. We show that the balance between the excitatory and the inhibitory synaptic inputs is critical in the formation of the functional structure, which is found to lie in a *self-organized critical state*.

- Keywords: Functional Neural Networks; Spike Timing Dependent Synaptic Plasticity (STDP); Complex Networks; Self-organized Criticality (SOC)

[PC-03] The Topological Properties of Protein-protein Interaction Networks

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We used the approach of small world and scale free theories to analyze the protein-protein interaction database DIP for seven species, including E. coli, H. pylori, C. elegans, D. melanogaster, H. sapiens, M. musculus and S. cerevisiae. Several global topological parameters were used to characterize the protein-protein interaction networks (PINs) for each species. According to the results of calculating these networks, we see that the logarithm of the node degree cumulative distribution P(k) vs. the logarithm of node degree k plots indicate that all the networks in PINs are well described in a scale free network, exhibiting the criteria of power law. In addition, after randomizing the results of all the seven species, we find that in these networks the clustering coefficients decrease largely and that the shortest paths increase in comparison with the original corresponding parameters of seven species. These findings suggest that the small world networks and scale free properties are the possible structures embedded in the protein-protein interaction networks rather than the random networks themselves.

- Keywords: scale free network, small world network, node degree cumulative distribution
- Related: P.H. Lee, K.L. Ng, P.P Wang, C.H. Huang, J.F. Fang, the proceeding of the CCAST meeting, Beijing, China (2005).

[PC-04] Complex networks with broadcasted nodes

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Recent studies on the complex networks are based on the assumption that the linker has all information about the entire network for wiring. In order to deal with this information locality problem , we propose a model with broadcasted nodes which uses only a fraction of global information together with local information. Numerical simulations with our broadcasted node model in 1-dimension shows the transition between exponential and scale-free networks as the threshold for broadcasting is varied.

- Keywords: network,sturcture,transition

[PC-05] Fractality and self-similarity in scale-free networks

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We study the origin of scale invariance (SI) of the degree distribution in scale-free (SF) networks with a degree exponent γ under coarse-graining. A varying number of vertices belonging to a community or a box in fractal analysis is grouped into a supernode where the box mass M follows a power-law distribution, $P_m(M) \sim M^{-\eta}$. The renormalized degree k' of a supernode scales with its box mass M as $k' \sim M^{\theta}$. The two exponents η and θ can be nontrivial as $\eta \neq \gamma$ and $\theta < 1$. They act as relevant parameters in the renormalization transformation and play a central role in determining the self-similarity as follows: The SI of degree distribution appears either when $\gamma \leq \eta$ or under the condition of $\theta = (\eta - 1)/(\gamma - 1)$ when $\gamma > \eta$, irrespective of whether the original SF network is fractal or non-fractal. Thus, the fractality and self-similarity are disparate notions in SF networks.

- Keywords: Fractality, Self-similarity, Coarse-graining, Box-mass distribution
- Related: cond-mat/0605324, cond-mat/0605587

[PC-06] Evolution of Weighted Complex Networks: Empirical Analysis and Modelling

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We investigate evolution mechanisms of weighted complex networks. By analyzing time-dependent data of four networked system, we found that external strength driven attachment is weak. But internal weight dynamics dominates the evolution of networks. Based on observed results, we proposed an evolving weighted network model. Our model gives power-law degree, strength and weight distribution. In addition, the ratio between external and internal dynamics is a key parameter of scaling between degree and strength.

- Keywords: Weighted Network

[PC-07] Relaxation dynamics of the synchronization on scale-free networks

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We study collective synchronization in a system of coupled oscillators on scale-free networks with the degree distribution given by $P(k) \sim k^{-\gamma}$. In particular, we pay attention to the relaxation dynamics of the synchronization, varying the degree exponent γ. It is found that t he relaxation time increases and displays almost saturated behavior for $\gamma \gtrsim 5.0$, implying the same relaxation time is required for the synchronization in the regime of low heterogeneity ($\gamma \gtrsim 5.0$). Interestingly, this saturation behavior is also shown in the phase diagram of the synchronization transition. In addition to the phase synchronization, the frequency entrainment is investigated by means of appropriate order parameter. The critical coupling strength at which the synchronization transition occurs is numerically obtained for both two kinds of synchronization, which shows a good agreement with the mean-field value for large γ.

- Keywords: synchronization scale-free network

[PC-08] A model of growing hierarchical scale-free networks

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We introduce a non hierarchical network growing mechanism, that furthermore does not impose explicit preferential attachment rules. This method consists of randomly selecting a existing nodes, and link a new node to m nodes among the selected node and its nearest neihbors. The resulting graphs feature power-law degree and clustering distributions, and manifest slightly disassortative degree-degree correlations. The rigorous rate equations for the evolution of the degree distribution and for the conditional degree-degree probability are derived.

- Keywords: complex network; scale-free network; hierarchical network

[PC-09] Effects of substrate network topologies on competition dynamics

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We study a competition dynamics, based on the minority game, endowed with various substrate network structures. We observe the effects of the network topologies by investigating the volatility of the system and the structure of follower networks. The topology of substrate structures significantly influences the system efficiency represented by the volatility and such substrate networks are shown to amplify the herding effect and cause inefficiency in most cases. The follower networks emerging from the leadership structure show a power-law incoming degree distribution. This study shows the emergence of scale-free structures of leadership in the minority game and the effects of the interaction among players on the networked version of the game.

- Keywords: minority game; complex network; scale-free network; game theory
- Related: Sang Hoon Lee and Hawoong Jeong, e-print cond-mat/0602295

[PC-10] Statistical properties of sampled networks

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We study the statistical properties of the sampled scale-free networks, deeply related to the proper identification of various real-world networks. We exploit three methods of sampling and investigate the topological properties such as degree and betweenness centrality distribution, average path length, assortativity, and clustering coefficient of sampled networks compared with those of original networks. It is found that the quantities related to those properties in sampled networks appear to be estimated quite differently for each sampling method. We explain why such a biased estimation of quantities would emerge from the sampling procedure and give appropriate criteria for each sampling method to prevent the quantities from being overestimated or underestimated.

- Keywords: sampling; complex network; scale-free network
- Related: Sang Hoon Lee, Pan-Jun Kim, and Hawoong Jeong, Phys. Rev. E 73, 016102 (2006)

[PC-11] Collaborative Blog Spam Filtering Using Adaptive Percolation Search

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We propose a collaborative blog spam filtering method to tackle the link spams in blogs. Our approach is based on a simple peer-to-peer trust building process and a novel information search algorithm called adaptive percolation search. We describe the distinguished features of our approach and show the efficiency of our method in eliminating spams. Our method exhibits high efficiency across wide range of parameters, while keeping the amount of communication overhead within an acceptable level.

- Keywords: Complex Networks, adaptive percolation search, blog-spam flitering
- Related: http://an.kaist.ac.kr/ syhan/blogspam.pdf

[PD-01] Dynamics of Bubble Shaped Line Defects in Period-2 Oscillatory Media

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Spiral waves that arise in period-2 oscillatory media extended in space generically bear "line defects" along which the local kinetics exhibits a period-1 oscillation. Locally, these defect structures can be viewed as a front separating two period-2 oscillatory domains oscillating 2π out of phase. Here we show that such line defects can also exist in various forms of simply connected loops (or "bubbles"), not being associated with a spiral core. In many cases, they are created spontaneously in various parts of the medium, grow initially, but shrink eventually to disappear. The shrinking process of bubbles involves two steps. The elongated bubble shrinks first only in the lateral direction perpendicular to the direction of the wave propagation until it becomes a circle, then shrinks evenly in every direction by reducing its radius. Simply closed line defects can also arise due to interactions among neighboring line defect, particularly, near the spiral core area. Once created, these bubbles ultimately decay. In others words, no "bubble" is stable. Very similar phenomena are also observed in computer simulations of a model reaction-diffusion system employing the Williamowski-Rssler kinetics.

- Keywords: Spiral, bubble, line defect, period-2

[PD-02] Effects of Non-Stationary processes and Position Dependen Flipping Rate on an On-Off Ratchet

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Brownian motor is the theoretical model that describes the motion of Brownian particles in asymmetric periodic potential. The main consequence is that unidirectional movement is induced in spite of unbiased driving force or potential modulation which is either periodic in time or stochastic process. This phenomenon is called ratchet effect.

In the last decade, Brownian motors have drawn much attention as the model of molecular motors. Recent experimental studies by means of one-molecular measurement technique suggest qualitative agreement with the perspectives according to Brownian motors, although the efficiency of Brownian motors is much smaller than those of actual molecular motors.

In this presentation, we discuss the extension of so-called on-off ratchet. On-off ratchet is one of archetypes of Brownian motors, in which periodic potential takes two states alternatively. In on state, potential has non-zero height, whereas potential is flat in off state. Switches from one state to the other take place stochastically. Mean velocity of the Brownian particle depends on the time scale of switching, and it is maximized at a certain switching probability. Bier and Astumian gave an intuitive explanation on how the current induced in on-off rathcet system with two assumptions, stationarity of switching processes and high potential barrier.

First we consider the case that the switching processes are non-stationary. In this case, residence time in each state (on or off) has broad (power law) distribution. We find that mean velocity of the particle becomes independent of mean residence time (time scale of switching) at the stationary/non-stationary transition point. As a result, on-off ratchet driven by non-stationary processes (NS ratchet) shows larger velocity than that of conventional on-off ratchet (S ratchets) at the fast switching regime, although maximum velocity is smaller than that of S ratchet. NS ratchet also shows larger velocity at the low temperature regime than that of S ratchet. We discuss that these behaviors can be explained from the residence time distribution.

Next, we show that the velocity and efficiancy of on-off ratchet could be largely enhanced by the introduction of position dependent flipping rate, and this effect can be thought as a stochastic resonance.

In the end of presentation, we shortly discuss these effects on collective systems, and the implication to the study of muscle contraction systems.

- Keywords: Brownian motor, sotchastic resonance, molecular motor
- Related: Nonlinear Phenomena in Complex Systems, in press Progress of Theoretical Physics 115 (2) : 455-450

[PD-03] Nonlinear dynamics of beam-column connections coupled with hysteretic dampers: Direct analysis and response prediction based on energy considerations

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This paper investigates the nonlinear planar vibration of a system constituted by a beam-column connection coupled with hysteretic dampers, under random dynamic transient excitations. The beam-column connection is formed by two horizontal members (i.e. the beams) and two vertical longitudinal members (i.e. the columns). One end of each member is hinged, and the opposite end is connected to the rest of the members by a rigid joint. The hinged ends are connected by four inclined longitudinal members (i.e. the dampers). The vertical displacements of all hinged ends are restrained. The horizontal displacements of the hinged end of one of the columns is also restrained, while the hinged end of the other column is subjected to randomly-applied dynamic forced horizontal displacements. The nonlinearity in the equation of motion of the system is due to material nonlinearity. This vibrating system plays an important role in studies of the dynamics of more complex mechanical systems, such as advanced building frames equipped with passive control devices subjected to severe earthquake-induced motions.

The nonlinear dynamics of the vibrating system for different mechanical properties of the members and for horizontal forces of varied frequency and amplitude content are studied through numerical simulations. Special attention is paid to the maximum horizontal displacement and to the residual permanent deformation of the system when the motion fades away. The coupled equations of motion resulting from a finite-element idealization of the mechanical system are analyzed directly by applying step-by-step integration methods. The results of the large number of numerical analyses carried out in this research show a wide array of dynamic behavior, but stable aspects of the responses can be identified. As a result of the numerical computations and a theoretical analysis based on the energy balance of the system, it is shown that the more relevant parameters of the dynamic response can be easily predicted. Simple formulae are proposed for that purpose.

Finally, the conclusions and formulae derived from the numerical simulations and the analytical study are validated by the results of an experimental study. In this study, a reinforced concrete wide beam-column connection equipped with four steel dampers was tested on a shaking table until collapse.

- Keywords: Hysteretic damping system; beam-column connection; nonlinear vibrations.

[PD-04] Chaotic stimulated Brillouin scattering near the threshold in a fiber

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We investigate a nonlinear dynamical behavior of the stimulated Brillouin scattering(SBS) near the threshold in the absence of feedback. When a cw Nd:YAG laser is injected into a single mode optical fiber, the SBS signal exhibits intermittently appearing irregular self-pulsations near the threshold. By examining the time series of the SBS signals, we can find that the irregular SBS signal is one of the chaotic phenomena appearing near the bifurcation point.

- Keywords: stimulated Brillouin scattering

[PD-05] Control of deterministic ratchet system via extended delay feedback

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We study the control of the drift property of deterministic inertia ratchet system via extended delay feedback. By adding the feedback terms of particle's velocities delayed by multiples of the orbit's period, we stabilize the unstable periodic orbit embeded in chaotic attractor of uncontrolled ratchet system. In addition to control of chaotic drift property of ratchet system into regular one, we present the new methods of particle seperation. We have shown that we can select the drift velocity and the drift direction of regular orbit by determining which one is stabilized among many unstable periodic orbits that have different mean velocities and different direction, as varying the parameters of extended delay feedback and particle's initial condition.

- Keywords: ratchet, delay feedback

[PD-06] Method of Asymptotics beyond All Orders and Restriction on Maps

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The method of asymptotics beyond all orders (ABAO) is known to be a useful tool to investigate separatrix splitting of several maps. We will briefly explain about the ABAO method with an example of the Harper map. Then, we consider 1 dimensional time discrete symplectic maps. We will show that the availability of the ABAO method restricts a form of potential. The result indicates that we need to expand the versatility of the ABAO method. More over, we check that the standard map, the H'enon map and the cubic map satisfy the restrcitions.

- Keywords: asymptotic expansion, separatrix splitting
- Related: nlin.CD/0606030,nlin.CD/0606033

[PD-07] Nonlinear Dynamics Study with Driven Cold Atoms

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Manipulation of neutral atoms in Magneto-optical trap(MOT) has opened unprecedented way of studying behaviors of many-particle systems in the past decade. Many works have been done from classical to quantum mechanical regime. However nonlinear natures of MOT have not yet fully discovered. We have studied nonlinear dynamics of cold atoms through parametrically driven MOT. Varying modulation frequency and amplitude, we have observed first and higher order of parametric resonances accompanied by Hopf bifurcation[1]. In particular, transition rates between double well generated by this bifurcation have been measured and compared with the famous Kramers' equation[2]. For theoretical description of this transition, averaging and variational method have been adopted which is recently developed to look into the fluctuational escape in dynamical system[3].

[1] Kihwan Kim et. al., Phys. Rev. A 68, 031403 (2003)
[2] Kihwan Kim et. al., Phys. Rev. A 72, 053402 (2005)
[3] M. I. Dykman et. al., Phys. Rev. E 57, 5202 (1998).

- Keywords: Magneto-optical trap, parametric resonance, Hopf bifurcation, transition rate, Kramers' equation

[PD-08] Chaos Theory for Relativistic Dynamical Systems

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The noninvariance of Lyapunov exponents in general relativity has led to an interesting discussion about the possible dependence of chaos on the choice of the space-time coordinates. Here, I will present recent results on how Lyapunov exponents and other dynamical quantities, such as metric entropy, topological pressure, and fractal dimensions, change under smooth changes of the time parameterization. I will discuss the significance of these results and of remaining open problems in the study of chaos in relativistic dynamical systems.

- Keywords: chaos, smooth time transformation, Lyapunov exponents, invariant measure
- Related: [1] A.E. Motter, Phys. Rev. Lett. 91, 231101 (2003). [2] K. Gelfert and A.E. Motter, to be published (2006).

[PD-09] Rotational dynamics of a diatomic solute in the room-temperature ionic liquid 1-ethyl-3-methylimidazolium hexafluorophosphate

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Reorientational time correlation functions $C_l(t)(\equiv \langle P_l[\theta(t)]\rangle)$ for a diatomic solute in 1-ethyl-3-methylimidazolium hexafluorophosphate ($EMI^+PF_6^-$) are analyzed via molecular dynamics computer simulations, where $\langle \ldots \rangle$ denotes an equilibrium ensemble average, P_l the l-th order Legendre polynomial and $\theta(t)$ the angle between the solute orientation at time t and its initial direction. Overall results are indicative of heterogeneous dynamics in $EMI^+PF_6^-$. For a small non-dipolar solute, $C_l(t)$ are well described as stretched exponential functions in wide time ranges. One striking feature is that after rapid initial relaxation, $C_2(t)$ decays more slowly than $C_1(t)$. As a result, the correlation time associated with the former is considerably longer than that with the latter. This is ascribed to solvent structural fluctuations, which allow large-amplitude solute rotations. As the solute size grows, relaxation of $C_l(t)$ approaches exponential decay.

- Keywords: room-temperature ionic liquid, rotational dynamics

[PD-10] Determination of Chaotic Dynamical Correlations in Terms of Unstable Periodic Orbits

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We find that chaotic time correlation functions can be accurately approximated by a single unstable periodic orbit. The method of this determination consists of the following two steps.

First, the time correlation functions are expanded in terms of static correlation functions by making use of the following method[H. Fujisaka, Prog. Theor. Phys. **114** (2005), 1]. We consider a chaotic mapping system,

$$\boldsymbol{X}_{t+1} = \boldsymbol{F}(\boldsymbol{X}_t) \tag{1}$$

(with $t = 0, 1, 2, \cdots$). Let us consider the time series of a single variable $u_t = h\boldsymbol{X}_t$, where $h\boldsymbol{X}$ is a unique scalar function of $\boldsymbol{X}$. If we define the time evolution operator L by $LG(\boldsymbol{X}) = G(\boldsymbol{F}(\boldsymbol{X}))$, then u_t obeys the equation of motion $u_{t+1} = Lu_t$. The time correlation function $C_t = \langle u_t u_0 \rangle$, where $\langle \cdots \rangle$ denotes the long time average, with u_t chosen such that $\langle u_t \rangle = 0$, can be obtained by following method. We introduce the vector variable

$$\boldsymbol{uX} \equiv (h_1\boldsymbol{X}, h_2\boldsymbol{X}, \cdots, h_{N+1}\boldsymbol{X})^T, \tag{2}$$

where $h_1\boldsymbol{X}$ is chosen to be identical to the function $h\boldsymbol{X}$ under consideration, and N is the number of new scalar variables, $h_2, h_3, \cdots, h_{N+1}$, and is assumed to be suitably chosen. The functions $h_1, h_2, \cdots, h_{N+1}$ are chosen to have components linearly independent from each other. Then, we define the vector variable

$$\boldsymbol{u}_t = L^t\boldsymbol{u}_0, \boldsymbol{u}_0 = \boldsymbol{uX}, \tag{3}$$

which obeys the equation of motion $\boldsymbol{u}_{t+1} = L\boldsymbol{u}_t$. With the projection operator method, this equation can be written in the form of the Mori equation of motion with a memory term. However, if N is suitably chosen, it is believed that the contribution from the memory term is small and can be ignored. Thus, we obtain the approximate relation

$$\boldsymbol{u}_{t+1} \approx \hat{\zeta}\boldsymbol{u}_t + \boldsymbol{f}_t, \tag{4}$$

where we have defined

$$\hat{\zeta} = \langle [L\boldsymbol{u}_0]\boldsymbol{u}_0^T \rangle \langle \boldsymbol{u}_0\boldsymbol{u}_0^T \rangle^{-1}. \tag{5}$$

The fluctuating force $\boldsymbol{f}_t$ is orthogonal to $\boldsymbol{u}_0$. Noting this property, the time correlation function $\hat{C}_t \equiv \langle \boldsymbol{u}_t\boldsymbol{u}_0^T \rangle$ obeys $\hat{C}_{t+1} \approx \hat{\zeta}\hat{C}_t$, which yields

$$\hat{C}_t \approx \hat{\zeta}^t\hat{C}_0. \tag{6}$$

The correlation function $C_t = \langle u_t u_0 \rangle$ is thus given by the 11 components of $\hat{C}_t$. It is thus found that the dynamical quantity $\hat{C}_t$ is determined by the static quantities $\hat{C}_0$ and $\hat{\zeta}$. We can extend this method to flow systems easily.

Second, these two static quantities, i.e. $\hat{C}_0$ and $\hat{\zeta}$, are approximated in terms of an unstable periodic orbit embedded in the strange attractor.

Thus the chaotic dynamical correlation functions can be determined in terms of an unstable periodic orbit. Furthermore, applying this method to a variety of chaotic models, we prove the usefulness of the present approach.

- Keywords: Chaotic Time Correlation Functions, Unstable Periodic Orbits, Projection Operator Method,
- Related: M. U. Kobayashi and H. Fujisaka, Prog. Theor. Phys. 115 (2006),701

[PD-11] Pattern dynamics in a rotating field

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We study the spatiotemporal dynamics of a one-dimensional anisotropic XY system driven by circulary polarized external field using the Ginzburg-Landau model. Temporal oscillation of uniform solutions are classified into five dynamic phases, namely, Symmetry Restoring Oscillation (SRO), Symmetry Breaking Oscillation (SBO), Quasi Periodic oscillation (QP), Symmetry Restoring Chaos (SRC), and Symmetry Breaking Chaos (SBC). Unifrom solution exhibits the dynamic phase transition betwen these phases by changing the amplitude or frequency of the external field.

Dynamical property of the spatiotemporal structure depends on the type of the uniform solution. In the case that two stable uniform limit cycles coexist, we observed the domain wall which connects two different limit cycles. The domain walls temporally oscillate in the presence of the periodic external field. Due to the symmetry of the model, there are two types of domain wall structures, achiral wall and chiral wall. In the case that the uniform solution shows chaotic oscillation, pulse-like random patterns are observed. In this presentation, temporal oscillation and the interaction of these patterns are reported. Approximation which describes the dynamics of the domain walls is also discussed.

- Keywords: dynamic phase transition, domain wall, nonautonomous system
- Related: N. Fujiwara, H. Tutu, and H. Fujisaka, Phys. Rev. E 70, 066132 (2004).

[PD-12] A study of correlation function in non-hyperbolic dynamical systems

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We study the dependence of statistical laws on initial ensembles and correlation function in non-hyperbolic dynamical systems. When the invariant measure is not finite, we demonstrate that time average of Lyapunov exponent and correlation function converges in distribution by numerical simulations. These results are consistent with Aaronson-Daring-Kac theorem.

- Keywords: Non-hyperbolic dynamical system, Ergodic theory, Infinite measure, Correlation function

[PD-13] Pulse Dynamics in Coupled Excitable Fibers: Crossing, Switching, Overtaking, and Spatio-Temporal Chaos

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We study the dynamics of a reaction-diffusion system composed of two laterally coupled excitable fibers. Especially, we focus on the situation where dynamical properties of two fibers are not identical due to the mismatch between the parameters of each fiber. Using the FitzHugh-Nagumo equation with diffusion as a model of single excitable fiber, we show that the system exhibits a rich variety of dynamical behaviors, including soliton-like waves, switching of synchronized pulses, and overtaking phenomena. Possibility of the occurrence of spatio-temporal chaos is also discussed.

- Keywords: coupled reaction-diffusion system, FitzHugh-Nagumo equation, soliton-like wave, spatio-temporal chaos

[PD-14] A new method for discerning the property of climate jump in China around the end of 1970s

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In the context of 1951 2000 June-August daily precipitation and temperature data at 740 stations of China compiled by China National Climate Center, the dynamical mechanism of anomalous summer climate in the neighborhood of the 1970s over the east of China is emphatically discussed from the angle of nonlinear dynamics by using dynamical correlation factor exponent Q. The main conclusions are as follows there are generally mean-value jumps for precipitation and temperature in China around the end of the 1970s, however dynamical analysis results show that the dynamical structure does not change in most areas, especially in the middle and lower reaches of the Yangtze River valley; both the mean-value and dynamical structure jump for precipitation and temperature of North China, and the persistent drought of North China after the end of the 1970s may result from its dynamical jump, which is associated with the large-scale topography of the Tibetan Plateau; dynamical jumps of precipitation and temperature over the Tibetan Plateau in accordance with with those over North China or even Northeast China; the analyses suggest that the teleconnection wave-trains triggered by the dynamical/thermal effects of the Plateau, disperse downstream-wards, causing the anomaly of the regional climate system in downstream regions; it is found via the analyzing of the tempo-spatial characters of the dynamical evolution for precipitation and temperature data that the dynamical background of climate system can be congruously reflected by different meteorological elements, while the statistic techniques hardly obtain this. The research has instructive significance for the study of the dynamical processes and predictability of climate system.

- Keywords: dynamics correlation factor exponent; nonlinear time series; climate jump

[PD-15] Nonlinear Dynamical Structure of precipitation in China and its Regional Climate Characters

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For a long time, the studies of climate prediction are limited to the traditional statistical linear methods, and when comes to the analysis of the regional characters of precipitation, the ocular estimate or EOF (Empirical Orthogonal Function) decomposition etc. are generally exploited. However, as a nonlinear phenomenon, precipitation dynamic can not be fully recovered with the common statistics. (?can not understand)In the light of the recent studies of nonlinear science, we reconstructed (the)dynamics of Chinese daily precipitation series from 1951 to 2000 at 740 stations with the time-delay method and then analyze the dynamics structure by using dynamical correlation factor exponent Q, yielding five significant climate regions differing from the conventional rainfall pattern. They are (1) Jianghuai pattern covering 65 meteorology observatory; (2) South China pattern covering 49 meteorology observatory; (3) North China pattern covering 59 meteorology observatory; (4) Northeast China pattern covering 27 meteorology observatory; and (5) Tibetan Plateau pattern covering 53 meteorology observatory. The statistical results show that precipitation in each region becomes dry, wet and normal simultaneously, that is to say, each region possesses a certain common spatial-temporal dynamics background. Further analysis of physical mechanisms indicates that the Jianghuai pattern and South China pattern are closely related to ENSO through the action of the IEA (India-East Asia) teleconnection mechanism; while among the other three patterns North and Northeast China patterns are positively related to the subtropical high pressure. The results show an important significance to develop regional climate prediction models.

- Keywords: dynamics correlation factor exponent; nonlinear time series; typical climate region

[PD-16] On Performance Differences of EMD and WD in the Nonlinear Time Series Analysis

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The procedure of the Hilbert transformation (HT) based on empirical mode decomposition (EMD) is first decomposing a nonlinear time series into its intrinsic mode functions (IMFs), then taking the HT of each IMF and computing the instantaneous amplitude and frequency. In the context of an ideal time series and the Guliya (located in Tibetan plateau) ice core (GIC) 18O time series, merits and defects of EMD and wavelet decomposition (WD) as well as HT and wavelet transformation (WT) in the nonlinear time series analysis are systematically analyzed/compared in this paper, and aiming at their defects, some proposals for possible improvement are also given. Research results show that, (1) In the EMD method, the mean value of upper and lower envelopes is used to determine the instantaneous balance position, and thereby get IMFs. The WD method is virtually a band-pass filtering, each detail component decomposed corresponds to a fixed frequency band, and therefore, the accuracy of the decomposition is worse than that of the EMD. In the WD, the configurations of the different wavelet base function and the decomposition levels have the great effect on the decomposition results, and how to select the wavelet basis function and decomposition levels is still a difficult problem to be solved; while in the EMD there is no such a problem. Meanwhile, there may be false components in the decomposition results for both two methods. With the computation of the (correlation coefficients)CCs among the IMFs, the detail components and the original time series, the principal IMFs and detail components, on which the remarkable signals of the original time series concentrate, can be picked out. Therefore, the combination of the EMD and the WD is able to identify the characteristic signals of the original series more effectively. (2) In the combination with the WT and the EMD-based HT, it is found that there might be about 30-, 70-, 130-, and 300-year variabilities for the GIC 18O time series in the past two thousand years. And the results are consistent with those from the Northern Hemisphere (NH) tree-ring series, the Dulan tree-ring series, and the Beijing Shihua cave stalagmite lamina thickness series. The facts suggest that there should be some intrinsic associations between different types of climate data, reflecting the same character of the climate system and belonged to the effect of the global change, which is of practical meaning for the analysis of the climatic data.

- Keywords: empirical mode decomposition; wavelet decomposition; Guliya ice core; Hilbert transformation; nonlinear time series analysis.

[PD-17] The Characteristics of power-law decay in Precipitation time series

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Precipitation sequence is a typical nonlinear or chaotic observational series, since a long period, studies on precipitation forecasts are limited in using traditional linear statistical methods, and especially when analyzing the regional characters of precipitation. In light of the recent research achievements of nonlinear science and with the daily precipitation sequence(1956∼2000) of 20 stations in south and north China compiled by the National Climate Center, we segment these 20 sequences into many self-stationary subsets using heuristic segmentation algorithm (BG algorithm), which can segment a time series into many self-stationary subsets, then we calculated the exponents of power-law tail (EPT) on the cumulative distribution of probability of segment with length larger than of each stations precipitation sequences, attempt to analyze the characteristics of precipitation in south and north China from a new aspect. Research results show that the feature of power-law decay i.e. the cumulative distribution of probability of stationary segments (divided by BG algorithm) with length larger than not only exists in precipitation sequences, but also in other nonstationary time series, i.e. temperature and physiological signals of heart rate et al. This feature of scaling law might be a common occurrence for precipitation and other nonstationary time series; The EPTs for 10 stations in north China (NC) varied between 1.6∼2.0, which are somewhat larger than the exponents of stations in south China (SC), varied between 2.0∼2.4. Meanwhile, the exponent of mean value precipitation sequences of all the stations in SC is 1.92, and NC is 2.54, therefore, EPTs of NC is comparing lager than SC. That is to say, the distribution of EPTs for precipitation might be different from area to area, which belong to different dynamical climate characteristic regions. Meanwhile, EPTs also varied with time, we divided them into four grades, most exponents of SC are fall in 3rd and 4th grades, while NC whose exponents are a little larger, most fall in 1st and 2nd grades. The exponents of SC have distinct abrupt changes before or after 1973a, 1980a and 1992a; meanwhile distinct abrupt changes of NC happened before or after 1971a, 1979a and 1990a, which is 1∼2 years before the former. The exponent of power-law can reflect the intrinsic properties of precipitation sequences, and its variation has close relation with the precipitation, so the abrupt change of exponent to some extent can characterize the APCs. EPTs might be another effective way to study the abrupt changes contained in nonlinear and nonstationary time series.

- Keywords: the power-law exponents, precipitation, abrupt precipitation change

[PD-18] Detecting the Abrupt Change of the Dynamical Structure of Non-Linear Time Series

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The study of abrupt change is an important aspect of the current non-linear time series research, however, the traditional abrupt change detection is mostly based on linear processes and analyses of the external character of data, therefore lacking solid physical base, and having limitations. How to Uncover the physical and intrinsic character of complex systems, i.e. how to detect the abrupt change of the actual series from dynamical aspect, is of particular significance. Aiming at the above problems, based on the dynamic correlation factor exponent Q (briefly Q exponent), which is an analysis method of the dynamical structure of time series based on the reconstruction of phase space, this paper combine Q exponent with heuristic segmentation algorithm which can divide a nonstationary time series into many self-stationary subsets, and presents a novel method-dynamical exponent segmentation algorithm (briefly Q algorithm) for detecting the abrupt change of dynamical structure. Through experiments of ideal time series the effectiveness of the method is examined, and it is also found that relatively less spike noises has smaller impact on the detection, but the continuous distributive random white noises have certain impact on the detection. Comparing the effectiveness of running T test, Yamamoto method, and Q algorithm in detecting the structural abrupt change point of time series suggested Q algorithm has merits, such as less false abrupt change points, distinctive abrupt change areas detected, and the definitude physical meaning of structural abrupt change point.

- Keywords: abrupt climate change, heuristic segmentation algorithm, anthropogenic change rate, little ice age, global change

[PD-19] Detecting Characters of North China and Global Climate Changes

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As well known, the climate system might be a complicated hierarchy consisted of multiple regional climate sub-systems, therefore, there must exist some intrinsic relation between local and global climate changes, but studies on theories and methods pertinent to the detection of abrupt climate change (ACC) are relatively rare. This paper introduces a new method-heuristic segmentation algorithm (BG algorithm) for detecting abrupt changes of non-linear/non- stationary time series, and applies BG algorithm to the high- and low-frequency sequences of the northern hemispheric (NH) tree ring width and the Beijng Shihua cave stalagmite lamina thickness sequence attempt to distinguish ACCs of different properties and to reveal their physical mechanisms. A new physical quantity-abrupt change density (ACD) is defined, and the anthropogenic influence on climate change is primarily explored by comparing the distributive characters of ACD between two consecutive millenaries. The intrinsic relation between local (the climate change in north China as an example) and global climate changes is investigated by the detection and analysis of the high-frequency sequence of the tree ring and stalagmite from different aspects. Research results show that, (1) BG algorithm is an effective method for detecting non-linear/non-stationary time sequences. BG algorithm is applied to treat the low and high frequency sequences, yielding the large- and small-scale abrupt change points (ACPs), respectively. That is to say, after the treatment of first-filtering-then-segmenting, it is possible to distinguish the abrupt change signal of different properties contained in the tree ring and stalagmite sequence. (2) Large scale abrupt changes of the low frequency sequences of S1(t) (tree ring width sequence) and S2(t) (Beijng Shihua cave stalagmite lamina thickness sequence) both occurred in about 380a, 900a, 1120a, 1350a and 1600a. The five ACPs divide the high frequency sequences of S1(t) and S2(t) into six mean value segments, and the analyses of ACP and mean value segments suggest that the character of precipitation in China was consistent with the large background of global climate change, to some extent suggesting that local ACC on the 100a or even longer time scale might exist; and the similarity of the dense abrupt change segments (DACSs) within various mean value segments of the two sequences S1(t) and S2(t) manifest that local and global climates changed synchronistically, the local climate change was constrained by the global climate system, meanwhile the local climate change might also have impact the character of global climate change. That is to say, the ACC in north China might be controlled by the global climate change. (3) Based on BG algorithm, viewing from the aspect of ACD, it is held that the worldwide little ice age might start at the beginning of the thirteenth century, ended at the end of the nineteenth century, and the sixteen century was the prime of the little ice age. Affected by the worldwide little ice age, the little ice age in China might start slightly later, at about the middle of the thirteenth century, and stopped at the end of the nineteenth century.

- Keywords: heuristic segmentation algorithm, abrupt change, abrupt change density, segments

[PE-01] Antipersistent Effects in the Dynamics of a Competing Population

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We consider a population of agents competing for finite resources using strategies based on two channels of signals. The model is applicable to financial markets and distributed control. We find that the behaviour of the system is determined by the correlation between the two channels. In particular, occasional mismatches of the signals induce a series of transitions among several attractors. Surprisingly, in contrast to the effects of noises on dynamical systems normally resulting in a large number of attractors, the number of attractors due to the mismatched signals remains small. Both simulations and analysis show that this can be explained by the *antipersistent* nature of the dynamics. Antipersistence refers to the response of the system to a given signal being opposite to that of the signals previous occurrence, and is a consequence of the competition of the agents to make minority decisions. Thus, antipersistence is relevant to the stability of dynamical systems.

We acknowledge the support of the Research Grant Council of Hong Kong (DAG04/05.SC36).

- Keywords: competing population, antipersistence, minority game, dynamical transitions

[PE-02] Detrended Fluctuation Analysis in Financial Exchange Market

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We analyze the won-dollar and yen-dollar exchange rates by calculating the probability distribution function of log returns in the financial exchange market. We apply the detrended fluctuation analysis (DFA) to detect the long range correlation embedded in the non-stationary time series. It is found in our case that there exist a persistent long-range correlation, which implies the deviation from the efficient market hypothesis. The crossover also is shown to exist in the scaling behaviors of the volatilities.

- Keywords: Detrended fluctuation analysis, Won-dollar and yen-dollar exchange rates, Scaling exponent

[PE-03] Cascades of Dynamical Transitions in an Adaptive Population

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Many natural and artificial systems consisting of a large number of agents are able to self-organize themselves to globally efficient states, while the individuals compete to maximize their own payoffs. In an adaptive population which models financial markets and distributed control, we consider how the dynamics depends on the diversity of the agents initial preferences. When the diversity decreases, the magnitude of the payoffs received by the agents increase. This change in the environment causes the system to adapt to different states, resulting in dynamical transitions from vanishing to non-vanishing step sizes. For systems with multi-dimensional signals, the dynamical transitions in each dimension do not take place at the same transition point. Rather, we find a cascade of dynamical transitions for the different signal dimensions, supported by good agreement between computer simulations and theoretical calculations. The asymmetric character in the different signal dimensions is statistically dependent on the initial condition of the system, with the signal of the largest step size at the steady state likely to be the initial signal.

Acknowledgement: This work is supported by the Research Grant Council of Hong Kong (DAG04/05.SC36).

- Keywords: adaptive population, minority game, dynamical transitions, diversity

[PE-04] Persistence probability analysis in major financial indices

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We analyze 38 world stock market indices, and compare the persistence properties of these countries. Our studies base on the persistence probability analysis of the critical behavior in an economic index, and the numerical estimation of the persistence exponent θ_p [1]. In many of non-equilibrium systems, the persistence has been found to decay as a power-law at time series, $P(t) \sim t^{-\theta_p}$.[2] Hurst exponent H_q[3] and persistence exponent θ_p in these financial time series are investigated in numerical and analytical.

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- Keywords: persistence probability
- Related: Critical dynamics and global persistence exponent on Taiwan financial market

[PE-05] Compexity analysis of stock market

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In this paper, we analyzed complexity of stock market by modeling ϵ-machine using causal-state splitting reconstruction (CSSR) algorithm. Datas of Standard and Poors 500 (S&P500) from year 1983 to 2006 are used for the analysis. We found that the statistical complexity has a tendency of decreasing and quantitative analysis showed that the efficiency of the stock markets dynamics became close to efficient market hypotheis (EMH).

- Keywords: Econophysics, computational mechanics, *epsilon*-machine, statistical complexity.

[PE-06] Business cycles and crises

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The efficient market hypothesis(EMH) is known to lead the market to the equilibrium point. Since the real economy is definitely far from equilibrium, it looks natural that the deviation from EMH, such as governmental interference, agents' collective behaviors and information cascades, should be pointed out to be the main reason. In a sense, however, the economy may have the intrinsic instability in its capitalistic mode of production: that is, even under the ideal conditions, it can exhibit a cycle or crises. We introduce its structure as a complex system and its qualitative behaviors which can be described by an epidemic model in the mathematical biology.

[PE-07] Group Dynamics of Japanese Market

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We investigated the temporally evolving network structures of the Japanese stock markets through the minimum spanning trees composed of listed stocks. We tested the validity of conventional grouping by industrial categories, and found a trend of decrease. This phenomenon supports the increasing external effects on the market due to the globalization of Japan. When we modified the stock price to minimize these external effects from the market, it is found a trend of increase on the grouping by industrial categoris.

[PE-08] Measuring the degree of common trends between multivariate time series

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We propose a novel approach for estimating the degree to which the whole trends of two time series are correlated. The study for measuring the similarity between trends of two time series has been important problem in the fields such as economics, geophysics and medical science. We introduce the Exit-time Correlation(EC) to measure this similarity by using Exit-time method which was recently considered as inverse statistics in economic time series. We also introduce phase-noise induced inverse fourier transform method to verify the usefulness of Exit-time Correlation through the comparison with Multiscale Cross Correlation(MCC). The Exit-time correlation is the inverse statistics for Multiscale Cross Correlation in analyzing correlation between multivariate time series. The application of our approach to high-frequency foreign exchange rates reveals that there is time organization structure in interaction between these data in long-range time scale.

[PE-09] Understanding Cross-Correlation in Financial Market.

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The complex interaction between the multivariate time series in the economic system have been studied actively in diverse research areas. This paper investigate about the nature of the interaction between the subunits in the financial system. We use the individual assets in the KOSPI and S&P500 stock markets from 1991 to 2003. In order to understand the various properties of the correlation matrix of the financial market, we propose the three type models such as random attachment(RA), average attachment(AA) and preferential attachment(PA) with a coupling strength with the power law and uniform distribution, respectively. We find that the distribution of correlation matrix of the economic time series deviate one from the random interaction, while shows a skew to positive direction. Notably, we find that the correlation distribution from the model with the preferential attachment with a coupling strength with a power law distribution with the exponent 3 is most similar to the correlation distribution of the KOSPI stock market. Our model also should apply to the EEG data, which has a positive skew of correlation distribution.

- Keywords: Cross-Correlation, Interaction, Financial Market

[PN-02] Delay correlation matrices

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We construct and analyze symmetrized delay correlation matrices both for random matrices and for empirical data sets. First we derive the eigenvalue density for the random delay correlation matrix constructed using independent identically distributed random data sets. The eigenvalue density is symmetric about the origin and has a square root singularity at the origin and is different from the standard semicircle law. We use the random matrix result as a null hypothesis for analysing the empirical data sets. The deviations from the random matrix results give us information about the correlations in the system. We analyze two contrasting empirical multivariate data sets; namely, (i) sea level pressure (SLP) in north atlantic region and (ii) the US stock market data. Using the analytical result as null hypothesis we are able to separate the noise component and determine the correlations. For the large eigenvalues the method acts as an excellent noise filter and we are able to identify different frequencies in the correlations. Most of the eigenvalues for the symmetrized delay correlation matrices for the stock data are symmetrically distributed about zero and are similar to the analytical results for the random data sets. However there are considerable deviations for the SLP data from the random case. For the SLP data we find long term correlations between different entities of the multivariable time series and we can identify different frequencies. For the stock data we find little correlations between different entities over a time delay beyond about two hours.

- Keywords: multivariate time series, random matrices

[PN-03] Statistical properties of δ-kicked quantum rotors

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The δ-kicked quantum rotor (QKR) is one of the most studiedparadigm of quantum chaos. The quantum dynamics of atoms subjectedto pairs of closely-spaced δ-kicks from optical potentials (for open boundary conditions) are shown to be quite differentfrom the well known single δ-kicked system [1]. The phase space in the classical counterpart is chaotic but ismade up fast diffusion regions which are separated by slow diffusing 'trapping regions', where the classical trajectoriesstick for a long time. The unitary matrix of the time evolution operator has a oscillating band structure corresponding to acellular structure of phase space. A spectral signature of a localisation-delocalisation transition from one cell to several has been investigated in [2]. The eigenstates (Floquet states) have localisation lengths which scale with afractional power h-0.75 unlike the standard δ kick with h-1. It has also shown a regime of near linearspectral variances which approximate the critical statistics relation $\sum 2(L) \simeq \xi L\ 1/2(1-\nu)L$, where ν 0.75 is related to the fractal classical phase spacestructure. The NNS statistics show the transition which gradually moves from Poisson to GOE and return to Poisson at the onset of delocalisation.

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- Keywords: delta-kicked quantum rotor, quantum chaos,Floquet states
- Related: PRL 96,024103(2006)

[PN-04] Spatio-temporal Chaos of three variable competitive Lotka-Voltera reaction diffusion equation

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We study the following diffusive Lotka-Volterra equation,

$$\begin{cases} \frac{\partial Y_1}{\partial t} = Y_1(1 - Y_1 - \alpha Y_2 - \beta Y_3) + \frac{\partial^2 Y_1}{\partial r^2} \\ \frac{\partial Y_2}{\partial t} = Y_2(1 - \beta Y_1 - Y_2 - \alpha Y_3) + \frac{\partial^2 Y_2}{\partial r^2} \\ \frac{\partial Y_3}{\partial t} = Y_3(1 - \alpha Y_1 - \beta Y_2 - Y_3) + \frac{\partial^2 Y_3}{\partial r^2} \\ (0 \leq Y_1(r,t), Y_2(r,t), Y_3(r,t) \quad \text{for} \quad [0 \leq r \leq L]) \end{cases} \tag{7}$$

where $Y_i = Y_i(r,t)$ is the population of the i species(i=1,2,3), α and β the parameters, and L is the system size. Equation (7) is the extension model considering the population movement. In the ground of the diffusive Lotka-Volterra system, many results was obtained by numerical and theoretical researches. Especially for the case of Eq.(7), the traveling wave and spatio-temporal chaos occurs[1-3].

We interest in Eq.(7) as the example of the spatio-temporal chaos in coupled heteroclinic cycles. At some different system sizes L, we will show the dynamical phase diagrams in α and β space, and the scaling law for the correlation length and time and the maximum Lyapunov exponent in spatio-temporal chaos regime.

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- Keywords: Turbulence, Spatio-Temporal Chaos, Lyapunov exponent, correlation length, correlation time, scaling law, Lotka-Volterra, reaction diffusion equation

[PN-05] Directional interacting whispering gallery modes in coupled dielectric microdisks

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We study the optical interaction in a coupled dielectric microdisks by investigating the splitting of resonance positions of interacting whispering gallery modes (WGMs) and their pattern change, depending on the distance between the microdisks. It is shown that the interaction between the WGMs with odd parity about y-axis becomes appreciable at a distance less than a wavelength and causes directional emissions of the resulting interacting WGMs. The directions of the emissions of relatively high-Q interacting WGMs depend on the refractive index inside cavities regardless of the distance between the microdisks and the wavelength of modes. The directionality of the interaction WGMs can be understood in terms of an effective boundary deformation in ray dynamical analysis.

- Related: arXiv:physics/0512055

[PN-06] Phase Slips in Superconduting Wires

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We study phase slip processes through superconducting wires. To analyze the phenomena, a master equation is employed. We investigate the current characteristic as a function of time. At $T = 0$, it is shown that first the current increases, then abruptly drops, and this pattern is repeated as a function of time. We attribute this to phase slip processes. We also consider respects due to finite temperature and correlation of wires.

- Keywords: phase slip, superconducting wire, master equation, and correlation

[PN-07] Transition from Strong to Weak Coherence Resonance in Excitable Phase Models

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We study the dynamical response to noise in the one-dimensional type-I excitable phase model with a parameter α ($0 \leq \alpha \leq 1$) tuning the degree of multiplicity in the stimulus. For $\alpha = 0$, the phase model is just the Adler equation subject to the additive stimulus, while it becomes the canonical type-I theta model for $\alpha = 1$. For the subthreshold case, the effect of noise on the oscillating characteristics is investigated by increasing α from 0. A characteristic correlation time τ_c has a maximum at some optimal noise intensity D^* (i.e., a maximally correlated state appears), independently of *alpha*. However, the phase model exhibits spectrally coherent or incoherent response to noise, depending on the value of α. For $\alpha = 0$, spectrally coherent response to noise occurs in the Adler equation (i.e., noise-induced peaks appear in the output power spectrum), and it is maximized near D^*. Thus, the Adler equation exhibits a "strong" coherence resonance occurs (i.e., a maximal correlation occurs along with spectral coherence resonance). However, as α increases and passes a threshold value α^* ($\simeq 0.45$), such a spectrally coherent response ceases because noise-induced peaks disappear in the output power spectrum for $\alpha > \alpha^*$. Thus, the phase model for $\alpha > \alpha^*$ exhibits a "weak" coherence resonance (i.e., a maximal correlation occurs without any spectral coherence). This kind of weak coherence resonance is confirmed in multidimensional physiological type-I neuron models such as the Morris-Lecar, Cornor, and Wang-Buzsaki models. Using the coefficient of variation, normalized fluctuation of interspike intervals are also discussed by varying α.

- Keywords: Excitable Phase Model, Coherence Resonance

[PN-08] Effect of gradual change in compressive direction on microwrinkle patterns

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Microwrinkles on a surface-modified elastomer spontaneously appear upon sample cooling due to the elicitation of mechanical frustration such as Euler buckling, and exhibit stripe patterns as widely found in nature. Surface strain states can strongly influence this pattern. While most studies have focused on the wrinkle formation and equilibrium states, little is known about the pattern stability and dynamics under external mechanical or thermal perturbations, which are important for technological applications. On this point, we have reported that, at room temperature, the complex pattern reversibly changes the stripe orientation depending on external strain, and the original pattern is remembered [1] and other related results [2-4]. Here, we will show the effect of gradual change in compressive direction on microwrinkle patterns. The regular motion of topological defects and the stripe reordering process will be analyzed and discussed[5].

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- Keywords: Wrinkle, Stripe pattern, Topological defect, Dislocation glide.

[PN-09] Experimental evidence of phase-slip bifurcation in delay coupled Chua oscillators

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A new type of bifurcation called phase-slip bifurcation is reported recently by the authors in delay coupled systems. When the delay time of two delay coupled systems is varied, the system shows sharp transition from inphase to antiphase synchrony at a critical value of the time delay. This bifurcation is accompanied by a large increase in the oscillation frequency. The phase-slip bifurcation is verified numerically in many systems, Rossler, Lorenz, Ginzburg-Landau system. Also this bifurcation is found to exist in different dynamical regimes like amplitude death, period-period, period-quaisperiod, chaos-chaos transitions. We present here the first experimental evidence of phas-slip bifurcation in two delay coupled Chua oscillators.

- Keywords: Phase-slip bifurcation, antiphase, delay coupling
- Related: 1. A.Prasad, Amplitude death in coupled chaotic oscillators, Phys.Rev.E 72, 056204 (2005)
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[PN-11] Self-Organized Criticality in a Simple Opinion Dynamical Model

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We present a simple opinion dynamical model showing the self-organized criticality. Each avalanche is caused by the tense triangular relation among three agents, e.g. one's friend's friend is not her friend. Tension is relaxed either by union process or by division process. We also introduce the tolerance that leads to the delay of relaxation but results in the extremely large avalanches.

- Keywords: opinion dynamics, self-organized criticality

[PN-12] Flow of Lennard-Jones Fluids in Nanochannel

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The nanoscale cylindrical Couette flow is investigated by means of molecular dynamics simulations, in the case where the inner cylinder is rotating whereas the outer cylinder is at rest. We find that the tangential velocity is inverted when the outer wall-fluid interaction is weak. The unusual velocity inversion behavior is shown to be directly related to the degree of the slip at the outer cylinder which is dependant of the particle density and the wall-fluid interactions.

- Keywords: Microchannel Flow, Molecular Dynamics

[PN-13] Stochastic model of chaotic phase synchronization

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As a stochastic model of chaotic phase synchronization(CPS), a continuous time system and a discrete time system subject to random force are introduced. It is shown that the transition from the phase desynchronized state to the phase synchronized state and the critical behavior of the CPS are reproduced by these models. While analytical treatment is performed for the continuous time model. Two different routes to CPS corresponding to the observation by Osipov et al. are explained by the discrete time model.

[PN-14] Phase Model Analysis of Coupled Neuronal Oscillators with Multiple Connections

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Synchronization of the coupled neuronal oscillators with multiple connections of different coupling nature is analyzed using the phase model reduction method. Each coupling connection contributes to the dynamic behavior of the system in a complex nonlinear fashion. In the phase model scheme, the contribution of the individual connections can be separated in terms of the effective coupling functions associated with each connection and a linear superposition of them provides the total effective coupling of the coupled system. The case of the multiple connections with various conduction time delays is also examined, which is shown to be capable of promoting synchronization over an ensemble of spatially distributed neuronal oscillators in an efficient way.

[PN-15] Wave-Particle Duality in an Open Chaotic System: a Quadrupolar Deformed Microcavity

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The extensive numerical analysis of a quadrupolar deformed microcavity will be presented compared with the experimental results. We have found that both the unstable manifold of ray dynamics and the openness of the system play crucial roles in explaining all the results obtained including espeically the so-called universal far-field emission directionality. It shows amazing correspondence between classical and quantum chaos in open systems.

- Keywords: Quantum Chaos Microcavity

[PN-16] Oscillatory Turing patterns in a simple reaction-diffusion system

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Turing [1] suggested that, under certain conditions, chemicals can react and diffuse in such a way as to produce steady state inhomogeneous spatial patterns of chemical or morphogen concentration. We consider the following simple two-variable reaction-diffusion system introduced by Barrio *et al*[2]. It is described by $\frac{\partial u}{\partial t} = D\delta\nabla^2 u + \alpha u + v - \alpha r_1 uv^2 - r_2 uv$ and $\frac{\partial v}{\partial t} = \delta\nabla^2 v - \alpha u + \beta v + \alpha r_1 uv^2 + r_2 uv$. We find there is a spatio-temporally oscillating solution (STOS) for Turing pattern which is unexpected since there is no Hopf instability or limit cycle for our chosen parameters where only stable spatially non-uniform solutions (SSNS) are known to exist.

We have found the boundary of the STOS and the SSNS phases in the r_1-$r_2$parameter space. There exits a critical constant c, determined by D, δ, α, β and the initial conditions, such that, when $\frac{r_2^2}{\alpha r_1} > c$, the system shows STOS, and when $\frac{r_2^2}{\alpha r_1} < c$, SSNS appears.

[1] Alan Turing, The Chemical Basis of Morphogenesis, *Phil. Trans. R. Soc. London* **B237** pp 37-72 (1952).

[2] R. A. Barrio, C. Varea, J. L. Aragón, and P. K. Maini, A Two-dimensional Numerical Study of Spatial Pattern Formation in Interacting Turing Systems, *Bull. Math. Biol.* **61**, 483(1999).

- Keywords: reaction-diffusion, oscillatory, Turing pattern

[PN-17] Simulation and experiment of horizontal size segregation

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When a monolayer spheres, which is subjected by a circular boundary, is applied with a circular polarized force, an intruder spheres will gain an intension to move to boundary or center depend on its size and density [1]. Molecular dynamics simulation is used to study this phenomenon. We consider only the pure rolling of sphere occurs and is caused by the friction with the supporting plate. The collision of spheres is modeled by a linear spring. Phase diagram of segregation, with the diameter ratio and density ratio as parameters, is obtained. The influence of driving force frequency and amplitude to the phase diagram has been discussed. The result is also compared to our experiment.

[1] T. Schnautz, R. Brito, C.A. Kruelle and I. Rehberg, Phys. Rev. Letts. 95, 028001(2005).

- Keywords: size segregation,granular physics,MD simulation

[PN-18] Domain size distribution in the TDGL system driven by the dichotomous Markov noise

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The domain size distribution of the time-dependent Ginzburg Landau equation driven by the dichotomous markov noise is discussed. It turns out that the ensemble average of the distribution function ($\langle n(l,t)\rangle$) for the domain size (l) exhibits a power law dependence ($\langle n(l,t)\rangle \propto l^{-\beta}$) with ($\beta \simeq 2$). A phenomenological time evolution equation of ($n(l,t)$) is further constructed and the cause of the power law dependence is investigated in terms of the evolution equation.

[PN-19] Bifurcation Analysis of Mode-locking Structure in a Hodgkin-Huxley Neuron under Sinusoidal Current

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Nervous systems under periodic stimuli display rich dynamical states including mode-locking and chaotic responses, which have been a subject of intense studies in neurodynamics. In this paper, the bifurcation structure of the Hodgkin-Huxley neuron under sinusoidal stimulus is studied in detail. The mechanisms of the firing onset and rich firing dynamics are studied with the help of the codimension-two bifurcations, which play the role of the organizing center for myriads of saddle-node, period-doubling, and inverse-flip bifurcations forming the boundaries of the complex mode-locking structure. This study provides a useful insight into organization of similar bifurcation structures in excitable systems such as neurons under periodic forcing.

- Keywords: Bifurcation, phase diagram codimension 1 bifurcation, codimension 2 bifurcation

[PN-20] $1/f$ spectrum in a fiber bundle model

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We study, via Monte Carlo simulations, a dynamic failure model exhibiting power laws in systems consisting of a large number of elements. Each element is allowed to be failed and healed with some conditional probabilities. Under external load the system shows the characteristic time evolution to the stationary state, which may or may not involve system-wide failure depending on stress and healing. When the parameters of the system is adjusted such as the fluctuation of surviving elements is large, $1/f$ behavior is observed in the power spectrum of the failure rate of elements. This happens because the system exhibits bistability and phase transition as we vary the healing parameter of the system which is under external stress with noise. For systems of local load sharing, a power law also appear in size distribution of failed elements when $1/f$ power spectrum is observed.

- Keywords: fiber, bundle, dynamic, failure, healing, stress, $1/f$ spectrum, phase transition

[PN-22] Self-Adaptation to Stable Periodic States in Chaotic Systems

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Control of chaos is one of the most important themes among researches on chaotic dynamics. Many methods for controlling chaos have been proposed since the seminal work by Ott, Grebogi, and Yorke. The constant feedback (CF) method is a simple control method, which converts a chaotic orbit to a stable periodic one by introducing a new parameter without a priori knowledge of the object system. However, the CF method requires an external adjustment of the parameter. We propose a new method for stabilizing a chaotic orbit to stable periodic one by a self-adaptive process that adjusts the parameter in the CF method. The parameter is no more constant but changing with time in the parameter space. In the proposed method, we consider mainly one-dimensional maps with the time-variant parameter. We assume that the object system can be described by a smooth nonlinear function, where periodic windows exist in the parameter space. This assumption generally holds for most smooth chaotic systems. The main processes of the method are as follows. The parameter changes its value every fixed time steps so that the largest value over the fixed time interval of time series of the system variable becomes the maximum in the object one-dimensional function. This procedure will be self-adaptive, because the parameter and the variable interact with each other without external control. We apply this method to several kinds of one-dimensional chaotic maps numerically, and confirm that chaotic states are stabilized to periodic ones in periodic windows. Since the method needs only observations and comparisons of the values for the system variable but not external adjustments, the method can be expected to work in broad class of chaotic systems. Indeed, we can also apply the method to the R"ossler system, which is a typical three-dimensional system that is continuous in time. As stated above, the proposed method is so simple that it may be applied to not only theoretical models but also some real world systems experimentally, e.g., neuronal systems and chemical reactions that can be reduced to one-dimensional maps.

- Keywords: chaos control, self-organization

[PN-23] Spatial Shift of Soliton in One-Dimension Lattice

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Solitons (or solitary wave) are very common in low dimensional systems and have many special properties. A well-known property is maintaining their shape and velocity when they move through a medium, for which the solitons strongly attract the most attention of the researchers. Another one is the spatial shift (jump) presents when they interact with the other quasiparticle of the medium. Although this property had been proposed as a scenario for a long time, the direct measurement has never been done, neither experimentally nor in a numerical simulation. For the first time, we quantitatively measure the spatial shifts of the solitons when they interact with others in one-dimension lattices. Two typical lattice systems, the Toda lattice and the FPU-β lattice, are considered to act as the spokesman of the integrable systems and the unintegrable systems, respectively. Since the velocity of the soliton is absolutely invariable in the integrable systems and almost invariable in the unintegrable systems if it does not interact with other solitons, we use a shrink time to measure the spatial shift. Numerical results show that the shrink time behaves quite differently in the FPU-β lattice and the Toda lattice. For example, it is sensitively related to the configuration of the soliton pairs in the former but negligibly in the latter.

- Keywords: Soliton, Scattering, Spatial Shift, Lattice System
- Related: None.

[PN-24] Shape Parameter Dependence of Emission Patterns from the Oval-Billiard Microcavity Laser Diodes

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We study the lasing characteristics of laser diodes with various shapes of oval-billiard families. These oval-billiard shape is characterized by a shape parameter delta, which covers from the integrable system ($\delta = 1$) to chaotic one (for $\delta = 0$) through mixed system (for $0 < \delta < 1$). These microcavity laser diodes are made of AlGaAs/GaAs SQW by using RIE dry-etching technique. The observed far field patterns show a pronounced structure that strongly depends on delta, that is, a cavity shape. Comparing the experimental data with the results of numerical simulation based on ray dynamical model, the good agreement could be yielded for all morphologies

- Keywords: oval billiard resonator, laser diode, ray chaos
- Related: Classical phase space by coherent light (submitted)

[PN-26] Transition from phase synchronization to lag synchronization in coupled lasers

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We experimentally investigate synchronization transitions in coupled laser diode pumped Nd:YAG lasers when the two lasers are electronically coupled. As a coupling strength increase, we observe a transition of laser outputs from non synchronization to phase synchronization. For a strong coupling strength, laser outputs transited from phase synchronization to lag synchronization though intermittent lag synchronization region. To clarify the transition to lag synchronization, we analyze the synchronization phenomenon by using a phase portrait, a similarity function, and error dynamics, we also obtain the scaling rule of the distribution of laminar length in intermittent lag synchronization state.

- Keywords: synchronization; Lag synchronization; Diode Laser; Nd:YAG Laser

[PO-01] General Theory of Amplitude-Modulation Atomic Force Microscopy

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The amplitude-modulation atomic force microscopy (AM-AFM), usually reffered to as the 'tapping-mode', is the one of the most widely used mode in AFM operation. This technique has demonstrated its ability to achieve not only solid-state sample images but also various biological images, to perform lateral manipulation of nano-objects, and to detect the tip-sample interaction forces.

In AM-AFM, the nanometric probe tip is excited by an external driving force in the close vicinity of the sample surface. During each oscillation cycle the nanoscale tip experiences a variety of short and long range forces such as van-der Walls, capillary, electrostatic, hydrodynamic forces. These interactions are highly nonlinear and consequently cause nonlinear dynamics of the probe tip.

Here we present a rigorous derivation of the general governing equations for the motion of the probe under both conservative and dissipative forces, as well as the characteristic differential equations describing the interaction forces from which the unknown interactions between the tip and sample can be unambiguously determined.

- Keywords: Atomic Force Microscopy (AFM), Nonlinear Dynamics

[PO-02] First Observation of KAERIs 10MeV Electron Beam Signals by CNU GEM Detector

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Performance tests of a single channel double GEM chamber constructed by the Radiation Detector Development Group of Changwon National University and a multi-channel double GEM chamber by the High Energy Physics Group of the University of Texas at Arlington have been carried out at the KAERI's RF accelerator 10MeV electron beams in May 20 - 26, 2006. In this experiment, we observed 10MeV electron beam signals from the detectors using oscilloscope and photographed a few waveforms. By analyzing the chamber output signals on the oscilloscopes, we were able to estimate the time profile of the KAERI 10MeV electron beam bunches. In addition, using this time profile, we are able to derive the spatial electron density distributions. Based on this derived electron density distributions, we performed an analysis of the chamber output signal pulse height distributions using the data collected through the DAQ system developed by the CNU RDD group. This experiment is significant since it is the first time the profile of the KAERI 10MeV electron beam has been observed through a detector.

- Keywords: GEM detector, KAERIs 10MeV RF accelerator, electron beam signals, beam bunch profile, pulse height distribution

[PO-03] Control of Emission light in Quasi-Stadium Micro-Cavity Laser Diodes

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We fabricated the AlGaAs/GaAs 3QW quasi-stadium laser diodes with two-electrodes and succeeded in controlling directional laser emission by applying different currents to each electrode. We showed the ratio of laser emission with two different directions is proportional to the ratio of currents injected into two electrodes. These devices are applicable for beam switching and splitting.

- Keywords: microcavity,semiconductor laser
- Related: Applied Physics Letters 88,211110 (2006)

[PO-04] The Lempel-Ziv Complexity in Infinite Ergodic System

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The large deviation property of the Lempel-Ziv complexity is studied by using a one-dimesional non-hyperbolic chaos map called "modified Bernoulli map", where the transition between stationary and non-stationary chaos is clearly observed. The upper limit of the Lempel-Ziv complexity in the non-stationary regime is theoretically evaluated, and the relationship between the algorithmic complexity and the Lempel-Ziv complexity is discussed. Non-stationary process is a universal phenomenon in non-hyperbolic systems, and is usually characterized by the infinite ergodic measure and intrinsic long time tails such as the $1/f^{\nu}$ spectral fluctuation.

It is shown that the Lempel-Ziv complexity obeys a universal scaling law, and that the Lempel-Ziv complexity has the L^1-function property which gurantees the Darling-Kac-Aaronson's theorem for the infinite ergodic system. The most striking result is that the maximum diversity appears at the transition point from the stationary chaos to the non-stationary one where the exact $1/f$ spectral process is generated.

- Keywords: infinite ergodic system, Lempel-Ziv complexity, f^{-nu} spectral process

[PO-05] Fuzzy Structure of Spacetime in Planck Scale

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The problem of reconciling quantum mechanics with general relativity is one of the task of modern theoretical physics which until now has not yet found a consistent and satisfactory solution. The difficulty arises since general relativity deals with the events which define the world-lines of particles, while quantum mechanics does not allow the definition of trajectory; in fact the determination of the position of a quantum particle involves a measurement which introduces an uncertainty into its momentum. These conceptual difficulties have their origin in the violation, at quantum level, of the weak principle of equivalence (universality of free fall) on which general relativity is based. Such a problem becomes more involved in the formulation of quantum theory of gravity, owing to the non-renormalizability of general relativity when one quantizes it as a local quantum field theory. Nevertheless, one of the most interesting consequences of this unification is that in quantum gravity there exists a non-vanishing minimal observable length on the order of the Planck length, $l_p = \sqrt{\frac{G\hbar}{c^3}} \sim 10^{-33} cm$. One can not set up a position measurement with uncertainty less than this minimal value. The existence of such a fundamental length is a dynamical phenomenon due to the fact that, at Planck scale, there are fluctuations of the background metric, i.e. a limit of the order of Planck length appears when quantum fluctuations of the gravitational field are taken into account. Existence of minimal length scale has been motivated by several promising candidates of quantum gravity and its consequences have been studied extensively. This natural cut-off guarantees the renormalizability of underlying quantum field theory. Also existence of this minimal cut off results in the modification of usual Heisenberg algebra to incorporate gravitational uncertainty from very beginning Non-commutativity of spacetime at quantum level led to spacetime fuzziness. Existence of non-vanishing minimal uncertainty in position cause un-determinability of spacetime points. In another words, locality is no longer possible and all events are uncertain at least up to Planck length. Spacetime in this viewpoint has a fractal or foamy structure. Recently a new point of view to this issue has been developed by El Naschie. In this novel scenario, fractal structure of spacetime in quantum gravity era has been formulated within Cantorian ($\mathcal{E}^{\infty}$) space. It seems that this scenario has the strong potential to be ultimate framework for unification of fundamental interactions and solves some mysteries of physics such as spacetime dimensionality, the nature of time in quantum gravity and some other key problems of modern physics. The fuzzy structure of spacetime has very novel implications for the rest of quantum theory. We will see that the picture of position space representation of usual quantum mechanics breaks down. Due to non-commutativity of spacetime, dispersion relations will generalize and as a consequence, waves profile will encounter anomalous dispersions. In addition, the notion of coherency and coherent states should be re-examined within this framework. In this paper, after an introduction to spacetime fuzziness, we discuss some of its consequences in the spirit of quantum theory. Position space epresentation, wave profile anomalous dispersion and the notion of coherency will be re-examined within fuzzy spacetime framework.

- Keywords: Spacetime Fuzziness, Wave Packet Propagation, Cohernt States
- Related: Part of it appeared in : hep-th/0508078

[PO-06] Dynamics of Harmonic Oscillator within Generalized Uncertainty Principle

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As a consequence of gravitational induced uncertainty, equation of motion for harmonic oscillator differs considerably from usual quantum mechanical situation. This paper considers the dynamics of a simple harmonic oscillator in the context of Generalized(Gravitational) Uncertainty Principle(GUP). Using Heisenberg Picture of quantum mechanics, we find time evolution of position and momentum operators. Our Calculation shows nonlinear evolution of operators due to quantum gravitational effect. We will show that expectation values of observables have an unusual complicated mass dependence. Also we will show that since the notion of locality breaks down, Ehrenfest theorem is not satisfied for harmonic oscillator in GUP.

- Keywords: Generalized Uncertainty Principle, Harmonic Oscilations, Nonlinear Evolution
- Related: gr-qc/0504090