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P01 Radar signals from adaptive chaotic maps

Thomas L. Carroll
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There has been interest in the use of chaotic signals for radar, but most researchers consider only a few chaotic systems and how these signals perform for the detection of point targets. In order to demonstrate that there is a much broader range of chaotic signals available, I use a chaotic map whose parameters may be adjusted by a numerical optimization routine, producing different chaotic signals that are modulated onto a carrier and optimized for different situations. It is also suggested that any advantage for these chaos-based signals may come in the detection of complex targets, not point targets, and I compare the performance of chaos-based signals to a standard radar signal, the linear frequency modulated chirp. I compare signal performance by using the cross correlation between transmitted and reflected signals, which is a standard radar technique.

P02 External periodic driving of large systems of globally coupled phase oscillators

T. M. Antonsen Jr., R. T. Faghih, M. Girvan, E. Ott and J. Platig
Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland USA

Large systems of coupled oscillators subjected to a periodic external drive occur in many situations in physics and biology. Here the simple, paradigmatic case of equal-strength, all-to-all sine-coupling of phase oscillators subject to a sinusoidal external drive is considered. The stationary states and their stability are determined. Using the stability information and numerical experiments, parameter space phase diagrams showing when different types of system behavior apply are constructed, and the bifurcations marking transitions between different types of behavior are delineated. The analysis is supported by results of direct numerical simulation of an ensemble of oscillators.

P03 Bifurcation analysis of reconnected equilibria in reduced resistive magneto-hydrodynamics

C. Tebaldi
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For reduced resistive magnetohydrodynamics the class of unreconnected equilibria defined by the magnetic flux $\psi(x)=\psi_2/\cosh^2(2x)$ and no motion has been considered in slab geometry. The sequence of bifurcations has been analysed, varying the aspect ratio ε as a control parameter for the magnetic shear at $x=0$, where magnetic field vanishes. Destabilization happens because of a symmetry-breaking bifurcation at $\varepsilon_c<\varepsilon_0$, where ε_0 is the stability threshold in the inviscid case, depending on viscosity. As a consequence a stable equilibrium with a small magnetic island and vortices appears. Further decreasing ε, the equilibrium with small island becomes unstable and a stable equilibrium with weaker symmetry properties appears, characterized by a magnetic island of the same size but a velocity field in the form of zonal flow and higher kinetic energy. The bifurcations involved are found to be a subcritical symmetry-breaking and a tangent bifurcation. When ε is further decreased the kinetic energy of the equilibrium strongly increases. The phenomenology, obtained for the first time, is considered relevant to the problem of enhancement of confinement in fusion plasmas.

P04 Where to place a hole to achieve a maximum escape rate

Leonid A. Bunimovich and Alex Yurchenko
Georgia Institute of Technology, Atlanta, Georgia USA

It is well known and obvious that the bigger the hole is the bigger is the escape through that hole. We determine a dynamical contribution to the escape rate. We consider the holes with equal sizes of strongly chaotic maps. In each hole one should find a periodic point of minimal period. The main result is that the faster escape occurs through the hole where this minimal period assumes its maximal value.

P05 Scalability of complex networks

Liang Huang[1], Ying-Cheng Lai[1,2], Kwangho Park[1] and Robert A. Gatenby[3]
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[2]Department of Physics and Astronomy, Arizona State University, Tempe, Arizona USA
[3]Department of Radiology and Applied Mathematics, University of Arizona, Tucson, Arizona USA

We address the fundamental issue of network scalability in terms of dynamics and topology. In particular, we consider different network topologies and investigate, for every given topology, the dependence of certain dynamical property on network size. By focusing on the network synchronizability, we discover that globally coupled networks and random networks are scalable, while locally coupled regular networks and scale-free networks are not. The findings are substantiated by analytic theory and numerical support. We expect our findings to provide insights into the ubiquity and workings of networks appearing in nature and to be potentially useful for designing technological networks as well.

P06 Selective spreading dynamics on complex networks

Rui Yang[1], Liang Huang[1] and Ying-Cheng Lai[1,2]
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[2]Department of Physics and Astronomy, Arizona State University, Tempe, Arizona USA

Spreading dynamics on complex networks have applications in many branches of science and engineering. Most previous studies are based on the assumption that a node can transmit infection to any of its neighbors with equal probability. In realistic situations, an infected node can preferentially select a targeted node and vice versa. We have developed a theory based on a set of exact rate equations to investigate this type of more realistic spreading dynamics on complex networks. Our analysis reveals that imposing selectivity has a significant consequence on the spreading dynamics. In particular, when small-degree nodes are selected more frequently as targets, infection can spread to a larger part of the network. On the other hand, preferential selection of the originally infected node by a target node can hinder effective spreading. Our analysis yields more accurate predictions about the spreading dynamics than those from the standard mean-field approach. Our findings not only provide a better understanding of spreading dynamics on complex networks, but also can be useful for developing practical strategies for efficient information propagation on technological or social networks.

P07 Defocusing fails for non-absolutely focusing components

Leonid Bunimovich and Alexander Grigo
Georgia Institute of Technology, Atlanta, Georgia USA

As is well known since the 1970's, dispersing and defocusing are the two mechanisms leading to hyperbolic behavior in billiards. Following these results, using special geometries of the tables, general recipes to construct hyperbolic billiards with dispersing and focusing boundary components were suggested, which essentially reduce to placing all other components sufficiently far away from any focusing pieces. In this talk we show that whenever a non-absolutely focusing boundary segment is used, these general strategies do not always result in hyperbolic tables. In fact, we show how this can lead to tables with stable periodic orbits of arbitrary long free paths. As a result of this, existing method of constructing hyperbolic billiards with focusing components must be restricted to absolutely focusing ones.

P08 Time-shifts and correlations in synchronized chaos

Jonathan N. Blakely, Matthew W. Pruitt and Ned J. Corron
US Army RDECOM, Redstone Arsenal, Alabama USA

We introduce a new method for predicting characteristics of the synchronized state achieved by a wide class of uni-directional coupling schemes. Specifically, we derive a transfer function from the coupling model that provides estimates of the correlation between the drive and response waveforms, and of the time shift (i.e., lag or anticipation) of the synchronized state. Notably, this approach does not require modeling or simulation of the full coupled system. To demonstrate the method, we apply it to a simulated system of coupled Rössler oscillators as well as to an experimental system of coupled chaotic electronic circuits. Finally, we show that the transfer function can be exploited to design novel coupling schemes that significantly improve the correlation and increase the maximum achievable time shift.

P09 Traveling waves in a network of Kuramoto oscillators with local coupling

Fatma GUREL KAZANCI[1] and Bard ERMENTROUT[2]
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[2]University of Pittsburgh, Pittsburgh, Pennsylvania USA

Winfree's ideas about studying synchronization of oscillators by looking at phase models in the weak coupling regime were implemented by Kuramoto using a simple yet non-trivial mean-field model. In this model, the oscillators are coupled through the sine of the phase differences. Over the years, many variations of this model have been studied, and yet some of Kuramoto's initial intuitions are still waiting to be proven.

We look at a variation of the Kuramoto model by considering a network of m groups each consisting of N oscillators. The oscillators are coupled in an all-to-all manner across the population and local coupling is only between groups. With this setting we observe traveling waves in the system. We study how the network behavior changes by the strength of local coupling and noise intensity.

P10 Impedance statistics and short orbits in wave chaos

James Hart, Thomas Antonsen and Edward Ott
University of Maryland, College Park, Maryland USA

The eigenfunctions and spectra of wave chaotic systems, i.e. systems described by linear wave functions, but possessing chaotic ray dynamics in the geometric optics limit, are notoriously sensitive to small perturbations of geometry. Thus statistical approaches have been developed to model such systems. In recent work, we developed statistical models to describe the response of these systems to external excitation. In particular, we have focussed on the scattering of electromagnetic waves into and out of a wave chaotic cavity, and determined a model for the cavity coupled to a number of small ports (antennas). The response of the cavity is described by the matrix impedance, which expresses the voltage at each port as a linear combination of the currents at all ports; with the only parameters being the radiation impedances of the antennas and volume and quality factors of the cavity. The results agreed well with experiment over sufficiently large frequency ranges, but over narrow ranges, systematic deviations from the predicted statistics appeared. We hypothesized that these deviations came from short, non-universal rays that went directly between antennas or to the wall and to the antenna.

In this presentation, we provide a theoretical reformulation of the statistics of cavity impedances where we constrain the statistics to be consistent with known nonuniversal short orbit contributions. Our main result is that the impedance statistics of our cavities with bounces are equivalent to treating the walls and the antenna combined as a single port within a larger cavity, with the universal statistics as predicted previously.

P11 Experimental evidence for mixed reality states in an interreality system

Vadas Gintautas and Alfred W. Hübler
Center for Complex Systems Research, University of Illinois at Urbana-Champaign, Urbana, Illinois USA

We present experimental data on the limiting behavior of an interreality system comprising a virtual horizontally driven pendulum bi-directionally coupled to its real-world counterpart, where the interaction time scale is much shorter than the time scale of the dynamical system.

We present experimental evidence that if the physical parameters of the simplified virtual system match those of the real system within a certain tolerance, there is a transition from an uncorrelated dual reality state to a mixed reality state of the system in which the motion of the two pendula is highly correlated.

As virtual systems better approximate real ones, even weak coupling in other interreality systems may produce sudden changes to mixed reality states.

P12 Predicting the growth of ramified networks

Alfred W. Hübler
Center for Complex Systems Research, University of Illinois at Urbana-Champaign, Illinois USA

We study the growth of ramified transportation networks in an electromechanical system [J. Jun, A. Hubler, PNAS, 102, 536 (2005)], where conducting particles self-organize into dendritic patterns for the purpose of collecting and transporting charge. The system forms stable open-loop networks with many reproducible statistical quantities, such as the number of termini and the number of branch points. However the final topology of the network is sensitive to the history of the system. Small perturbations may lead to very different outcomes. We present robust and reliable ensemble prediction algorithms for the growth of such fractal transportation networks. These predictors may lead to the discovery of common properties and serve a prototype to predict fractal growth in other areas, including neural systems; blood vessel systems, river networks, and dielectric break through.

P13 Finding dynamical information in short, noisy and sporadic data streams

Linda Moniz and Rich Wojcik
Applied Physics Lab, Johns Hopkins University, Baltimore, Maryland USA

Streams of epidemiological data are very short and noisy in comparison to other data on which time series analysis is usually performed. In addition, it is often sporadic; missing data is a common occurrence. However, these are the only data that are available (one cannot re-run a flu season on an entire population because the data are bad) and analysis of these data are all we have to predict and identify important events.

In this work, we consider time series of counts of ill individuals (either from patient encounters, lab orders, radiology orders or a combination of these). We modify the continuity test and a prediction algorithm to work with sporadic data, and also use Bandt and Pompe's permutation entropy to investigate the dynamics of the time series. Our emphasis is on determining what the data can tell us and what it cannot. Using these techniques, we can identify similarities in dynamics across monitored locations and also identify attributes of the time series for which the metrics cannot be trusted to give meaningful results.

P14 Wavelets meet Burgulence: CVS filtered Burgers equation

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We solve numerically the 1D inviscid Burgers equation coupled to a wavelet based nonlinear filter in a way similar to CVS (Coherent Vortex Simulation). The nonlinear filter consists in retaining only the largest coefficients of a translation invariant wavelet reprensentation of the velocity, without requiring any parameter adjustment. We use a conservative pseudo-spectral scheme with a finite number of Fourier modes and we check that without filtering the steady state solution corresponds to energy equipartition.

In contrast, with CVS filtering we show that the solutions approach those of the viscous Burgers equation.

P15 Time-shifted synchronization of passband chaotic electronic oscillators

Mark T. Stahl, Ned J. Corron and Jonathan N. Blakely
US Army RDECOM, Redstone Arsenal, Alabama USA

We demonstrate time shifted synchronization of two passband chaotic audio-frequency electronic oscillators. Each oscillator consists of a slow chaotic Lorenz circuit that drives a fast periodic circuit. Thus the each oscillator contains two separate characteristic timescales. Linear difference coupling between the chaotic systems and, separately, between the periodic systems causes identical synchronization. Introducing an appropriate detuning of the parameters that govern the timescales produces lag or anticipation on both the fast and slow timescales. These results suggest a mechanism for power combining and beam forming with passband chaotic signals.

P16 Transfer entropy and the Nyquist criteria

Christopher W. Kulp[1] and Eugene R. Tracy[2]
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[2]Department of Physics, The College of William and Mary, Williamsburg, Virginia USA

In this poster we investigate the application of a quantity known as the transfer entropy to unevenly spaced time series. The transfer entropy can determine the rate and direction of information exchanged between two evenly spaced time series. Here we apply the transfer entropy to two time series generated from the driven harmonic oscillator. These two series have a known driver/response relationship. We randomly remove elements from each series to test how well the transfer entropy identifies the correct driver/response relationship when the series are no longer evenly spaced. We find that once the level of depletion surpasses some threshold, the transfer entropy can no longer correctly identify the driver/response relationship. Further, we show that as long as the sampling frequency of the depleted series satisfies Nyquist's criteria, then the transfer entropy correctly identifies the driver/response relationship.

P17 Experimental investigation of the chaotic waterwheel

George Rutherford, Richard F. Martin, Jr., Epaminondas Rosa, Jr. and Amy Erxleben
Illinois State University, Normal, Illinois USA

The chaotic waterwheel is often given as an example of a mechanical system that can exhibit chaotic behavior. Its early demonstration by Malkus and the realization that it can be modeled by the Lorenz equations has secured it a prominent place in almost every general presentation of chaos. It seems quite surprising, then, that no experimental investigations of this textbook system have ever been published. To fill this historic gap, and to initiate an experimental study of this incredibly rich dynamic system, our lab has constructed a research-grade waterwheel consisting of a vacuum-formed polycarbonate frame in which 36 cylindrical cells are mounted on an 18 inch diameter. The wheel and its axis can be tilted, and water is fed into the top of the wheel and drains out through thin tubes at the bottom of each cell. An aluminum skirt at the wheel's periphery passes through a variable gap magnet to provide magnetic braking. Angular time series data are collected with an absolute rotary encoder. The data are smoothed and angular velocity and acceleration are calculated via fast Fourier transforms. The data show quasi-uniform rotation as well as periodic and chaotic motion and agree fairly well with computer simulations of the idealized wheel equations. Uniform rotation trajectories show small oscillations about the fixed-point velocity, and it is unclear whether this is a manifestation of a small imbalance in the wheel, the stochastic nature of the input water flow, or some other mechanism. Stable, long-lived uniform rotation also persists for parameters beyond those predicted by the simulation. Periodic motion is robust over a broad parameter range, although it is marked by significant excursions from the periodic attractor long after initial transients have disappeared. Period-two motion is resolved, but higher period orbits merge into a single band of orbits as the braking parameter is increased toward values that give chaotic motion. We will show experimental and model bifurcation plots using the braking strength as the relevant parameter. Plans for future studies will also be presented.

P18 Predicting cardiac alternans based on empirical stability analysis

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Cardiac alternans is a marker of ventricular fibrillation, a fatal heart rhythm disorder that kills hundreds of thousands of people in the US each year. Alternans is manifested as a beat-to-beat alternation in action potential duration (at the cellular level) or in ECG morphology (at the whole heart level). According to the theory of dynamical systems, cardiac alternans is mediated by a period-doubling bifurcation, which is associated with variations in a characteristic eigenvalue of the Jacobian matrix. Thus, knowing the eigenvalues would allow one to predict the onset of alternans. Utilizing the condition on eigenvalues, the existing criteria for alternans are based on hypothesized relations between action potential durations in consecutive beats. Although these criteria approximate some experiments well, they do not apply to all situations because the underlying models may not be universally valid.

In this work, we propose a model-independent technique to estimate a system's eigenvalues without a priori assumptions of the underlying dynamic model. The method consists of two steps. In step one, we construct a pseudo state space, utilizing the concept of delayed coordinates. The pseudo state can be formed using the time history of one or multiple measurable variables, e.g., the transmembrane voltage and the intracellular calcium concentration in cardiac experiments. In step two, we estimate the dominant eigenvalues contained in the pseudo state vectors using statistical analyses. We have developed two techniques based on principal component analysis and maximum likelihood estimation. Applying these techniques to data generated by a computer model of cardiac action potential shows that they are able to accurately predict cardiac alternans. Since the techniques do not depend on any specific model, they can be readily applied in other dynamical systems and to experiments.

P19 Temperature effects in a continuum model for flocking

Nicholas Mecholsky, Edward Ott and Thomas Antonsen
Institute for Research in Electronics and Applied Physics, University of Maryland, College Park, Maryland USA

The modeling of the dynamics and configurations of animal groups has recently been the subject of renewed attention. We present a continuum model of flocking and investigate its properties in the case of a time-independent one-dimensional flock. Our approach includes a term modeling local velocity dispersion of individuals in the flock (analogous to temperature in a gas). In the absence of this 'temperature', we are able to analytically extract a parameter-space phase diagram showing where flock-like (i.e., localized) solutions exist. We then compare this analytical, zero-temperature solution to numerical solutions for the case in which velocity dispersion (temperature) is included, and we investigate the approach of the solution with temperature to the solution without temperature. We find that the zero temperature result is extremely sensitive to the introduction of even a tiny temperature. This suggests that inclusion of velocity dispersion is essential in formulating a reasonable flocking model.

P20 Rotating Space Elevator

Steven Knudsen and Leonardo Golubovic
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Ever since an early vision of Tsiolkovsky, the concept of space elevators connecting the Earth with heavens has intrigued researchers in classical mechanics and aerospace science, as well as science fiction writers. Here, we feature a novel nonlinear dynamical system we call Rotating Space Elevator (RSE). The RSE is a multiply rotating system of cables reaching distances some forty-thousand miles away from the Earth. A fascinating dynamical feature of the RSE multiple rotation motion is that it provides an efficient mechanism for moving of sliding climbers, all the way from the Earth surface to deep space destinations. Strikingly, unlike previously suggested space elevator designs, useful loads and humans moving along the RSE cable do not require internal engines or propulsion to be transported far away from the Earth's surface. This solves the major problem of energy supply to climbers which troubles the ordinary space elevator technology.

P21 Evaluation of nuclear fallout contamination of the Semipalatinsk test site

Gulzhan OSPANOVA, Zhanel MAILIBAYEVA, Manat TLEBAYEV, Maira MUKUSHEVA
Kazakh National Technical University, Almaty, Kazakhstan

Atomic test polygons that were actively operated on the territory of Kazakhstan for four decades have caused a considerable damage to the environment in the republic. Approximately 70% of total nuclear tests of the former USSR were carried out in Kazakhstan. Most of them including air and surface explosions were conducted at Semey Nuclear Polygon (SNP) near the city of Semipalatinsk. Total of 456 nuclear explosions were made between 1949 and 1989, as well as tests of the first atomic (1949) and hydrogen (1953) bombs. Thus, SNP is one of the main sources of radiation hazard for the population of Kazakhstan.

As a result of nuclear explosions at SNP 9×10^{16} Bq ^{137}Cs entered into the environment. Today, 18 years after the last explosion, the level of biologically significant long-living radionuclides in soil still exceeds the acceptable concentration. Therefore, long-living radionuclides migration is an urgent problem in SNP area. Nuclear tests caused irreplaceable damage to the health and environment. General prevalence of diseases and the death rate of the population increased considerably.

Nowadays, access to the territory of SNP is open. Radiation situation is still evolving. Research shows that effects of second contamination began to appear. These include: radionuclides migration with underground waters, radioactivity transfer on the earth surface by melted and downpour waters, wind transfer and radionuclides migration through food chain. Long-living radionuclides are accumulating in agricultural produce and animals. Thus, the problem of transferring of long-living radionuclides into the soil-vegetation-animal system is of paramount importance.

Analysis of the current radiation situation at the test site; radispectrometric and radiochemical examination of samples of soil, plants, water and biological objects; statistical processing of sample examination results; complex of physical models for radionuclides migration were carried out.

The evaluation of the nuclear fallout contamination of the Semipalatinsk test site is based on the system analysis which includes the following factors: 1) calculation of radionuclides migration in the following systems: "soil-plant", "plant-animal" and "water-animal"; 2) simulation of ^{137}Cs, ^{90}Sr radionuclides

distribution in the soil-plant-animal system of “critical” sites; 3) calculation of ecological parameters in order to reveal the population radiation doses for the purpose of economic usage of critical sites.

We developed the methodology of evaluation of the nuclear fallout contamination, prediction of consequences of radioactive contamination of Semipalatinsk test site environment and measures of risk reduction.

P22 Carbon nanotubes obtaining technology

Gulzhan OSPANOVA, Manat TLEBAYEV, Timur BAYZHUMANOV, Eleonora KOLTSOVA
Kazakh National Technical University, Almaty, Kazakhstan

Nanotubes usage is huge. Methods of hydrocarbon catalytic pyrolysis are very perspective for obtaining of carbon nanotubes and nanofibres. Technological scheme of catalitical methane pyrolysis with obtaining of carbon nanotubes, nanofibres and hydrogen is developed. Kinetic scheme of methane catalytic decomposition with usage of nickel catalysts at 500 - 1000° for carbon nanotubes, nanofibres obtaining is developed. Catalytical decomposition of carbon containing raw scheme is created. Optimal parameters of carbon nanotubes and nanofibres formation from methane are determined. Microphotographs of obtained methane catalytic pyrolysis products with usage of different catalysts are made. Equipment for methane catalytical pyrolysis is created. Application of carbon nanofibres and nanotubes is given. Economic effectiveness of methane catalytical decomposition with obtaining of carbon nanotubes, nanofibres and hydrogen is calculated. Is shown the cost of 1 kg of carbon nanofibres is $11.2-18.7 and the cost of hydrogen depends on its purity is $22.4-82.3. We developed economical efficient technology for obtaining of carbon nanotubes, nanofibres.

P23 Inertial effects on Lyapunov exponents

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The Lyapunov exponents (LE) are indicators of chaos in a dynamical system. But, if the system is moving as a whole, could the LE change? Would it be necessary to correct LE evaluated in moving frames? We investigate the effect of a rotating the frame on the evaluation of LE, answering yes to both questions.

P24 Finite Larmor radius effects on non-Gaussian chaotic advection of tracers in plasmas

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[2]Oak Ridge National Laboratory, Oak Ridge, Tennessee USA

We investigate models for chaotic advection based on the Hasegawa-Mima limit of the gyrokinetic equation for a magnetized plasma. These prescribed streamfunction models exhibit Lagrangian stochasticity for passive tracer particles in the flow.

In particular, particles execute sticky-flights as they drift between vortices and surrounding zonal flows. We give the ensemble of tracers a Maxwellian distribution of gyroradii, which allows us to report on finite Larmor radius effects.

Measurements of transport for an ensemble of tracers reveal non-Gaussian scaling of the first two moments. We also show that the shape and the spatio-temporal scaling of the Lagrangian propagator can be modeled with fractional diffusion equations currently used to study non-local transport in plasmas.

P25 Fluctuation-driven directed transport in the presence of Lévy flights

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[1]Oak Ridge National Laboratory, Oak Ridge, Tennessee USA
[2]Institute for Theoretical Physics NSC KIPT, Ukraine

Numerical evidence of directed transport driven by symmetric Lévy noise in time-independent ratchet potentials in the absence of an external tilting force is presented. The results are based on the numerical solution of the fractional Fokker-Planck equation in a periodic potential and the corresponding Langevin equation with Lévy noise. The Lévy noise drives the system out of thermodynamic equilibrium and an up-hill net current is generated. For small values of the noise intensity there is an optimal value of the Lévy noise index yielding the maximum current. The direction and magnitude of the current can be manipulated by changing the Lévy noise asymmetry and the potential asymmetry.

P26 Targeted activation in high dimensional inertial systems

Bryan Eisenhower and Igor Mezic
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Many dynamical systems in nature have multiple conformed states and transition between these states is one of their integrated functions (e.g. biomolecules). Understanding the efficient and robust approach nature takes to accomplish this switching between large scale coherent states leads to tools for the design of integrated engineered systems. These systems include but are not limited to dynamics of coordinated agents (e.g. unmanned flying), crowd control, materials processing, and others. Our work investigates an efficient mechanism for conformation change in a biological macromolecule with the intention of applying this understanding to the analysis and design of other systems. This macromolecule has two global equilibria and we qualify and quantify the most efficient method of activation from one of the metastable states leading to conformation change. Unlike the historical study of reaction dynamics, the processes here are nonstatistical and deterministic. We show that a series of canonical transformations leads to a model description that highlights the factors that dominate conformation change. We also highlight that internal resonance of actions in this high dimensional model is key in the energy exchange process leading to conformation change. It turns out that a well defined geometric structure dominates during the essential energy transfer in resonance. In essence a digraph structure becomes a clearly evident pathway for the transfer of modal energies supporting the energy cascade that leads to conformation change. We summarize the work with a series of tools which have predictive capability that capture the essential behavior of conformation change through activation.

P27 The effect of crowding on rod ordering

Jennifer Galanis[1] and Daniel Harries[2]
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[2]The Hebrew University of Jerusalem, Jerusalem, Israel

Crowding can modify the interactions between particles. An important driving force behind this effect is excluded volume minimization, as determined by the size, shape, and density of the particles. Using vibrofluidized granular materials and equilibrium Monte Carlo simulations, we investigate crowding and confinement in a 2D system composed of two particle shapes (rods and spheres). It is known that in a

pure rod system, high enough densities induce a transition from a disordered (isotropic) to an orientationally ordered (nematic) phase. We find that the inclusion of spheres destabilizes the nematic state in both experiments and simulations, and small independent clusters of rods form, instead. As both rod and sphere densities increase, these aggregates further self assemble to form polymer-like structures.

P28 Spatial-temporal chaos without nonlinear dynamics

Ned Corron
U. S. Army RDECOM, AMSRD-AMR-WS-ST, Redstone Arsenal, Alabama USA

A continuum limit for an iterated shift map reveals a linear filter driven backward in time. The limit is derived by factoring the shift iterate into an arbitrarily large number of identical fractional iterates. Application to a coupled map lattice (CML) of shift maps results in a spatially extended filter, revealing a linear decomposition of chaotic spatial-temporal dynamics. A consequence is the capability to construct spatial-temporal chaos via linear synthesis and convolution. This unnerving result undermines the usual assumption that deterministic chaos results only from the evolution of a nonlinear dynamical system.

P29 Nonlinear state and parameter estimation — The methods of optimal tracking and dynamical coupling

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Estimating the parameters of a nonlinear dynamical model using observed data is an important aspect of developing predictive models of physical and biological systems. Building on existing work that uses synchronization as a tool for parameter estimation, we show the equivalence of this problem to that of tracking within an optimal control framework. This equivalence allows the application of powerful numerical methods that provide robust practical tools for model development and validation. We present numerical simulations demonstrating the applicability of this method to estimating the states and parameters of several systems including Lorenz, Colpitts, and the Hodgkin-Huxley spiking neuron model. We then apply this method to data measured from electrical circuit representations of each of these systems. The dynamical coupling method, where the coupling strength obeys its own differential equation driven by an error signal, is also demonstrated with these same data sources.

P30 Possible chaotic underpinnings for quantum mechanics: Applications to Bell's inequalities and chaotic scattering

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Could it be possible that modern chaos theory might resolve the age-old debate between Einstein and Bohr over the interpretation of quantum mechanics? Chaos theory provides the determinism so dear to Einstein; yet it must be interpreted statistically, in line with the Bohr-Copenhagen school. Thus, it could provide a bridge between the two diverse viewpoints. More to the point is that at least seven of the so-called paradoxes raised by the Copenhagen interpretation have more logical parallel interpretations according to chaos and nonlinear dynamics. These include statistical exponential decay laws (exponential sensitivity to initial conditions), parity nonconservation (spontaneous symmetry breaking), wave-particle duality (order in chaos), and perhaps even quantization itself (common in many classical nonlinear systems). I shall give an overview of current understanding, then concentrate on the breaking of Bell-type

inequalities and the application of chaotic scattering to paradoxes of the two-slit experiment. (Bell's inequalities are currently important for investigating the fundamentals of quantum theory; they provide statistical correlations between pairs of distant entangled particles and have been used to rule out the existence of local reality, i.e., favoring Einstein's "spooky action at a distance." Chaotic scattering requires at least second-order equations and thus may be a possible way to explain the "which path" [*welcher Weg*] paradoxes encountered in double-slit experiments.) The founders of quantum mechanics did not have access to modern nonlinear dynamics or chaos theory, so quantum theory was forced to develop along strictly linear lines. Had chaos theory (and modern computers to handle the numerical data and graphics) been available, quantum mechanics might well be far less paradoxical.

Reference: Wm. C. McHarris, Chaos Meets Quantum Mechanics: Possible Nonlinear Vindication of Einstein's Arguments (invited paper), Complexity, Vol. 12, Issue 4 (March/April 2007), p. 12, and references therein.

P31 Application of nonlinear dynamical analysis for the study of gastrointestinal circulatory pathophysiology

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Although cardiac arrhythmias have been studied extensively using nonlinear dynamical analysis, little is known about arrhythmic phenomena in the gastrointestinal (GI) system. In this study, we demonstrate for the first time that the onset of GI arrhythmias is associated with statistically significant fluctuations in the information dimension of the associated chaotic systems. We induced gastric and intestinal arrhythmias in pigs using surgical stomach division and mesenteric artery ligation, respectively. Both conditions lead to a decreased supply of blood to the GI tract, which is associated in humans with various potentially lethal conditions including chronic mesenteric ischemia, whose mortality rate is over 60 %. During our experiments, we recorded simultaneous magnetocardiographic, magnetogastrographic and magnetoenterographic signals and concluded that, when GI circulation is compromised, the information dimensionality of the chaotic system fluctuates significantly. Moreover, significant changes in return map characteristics were observed. In conclusion, chaotic system dimensionality may be an important diagnostic factor for the characterization of arrhythmias in the context of GI pathophysiology.

P32 Complex behavior of blackouts in electric power systems

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A model has been developed to study the complex behavior of blackouts in power transmission systems. This model includes a simple level of self-organization by incorporating the long-term forces acting on the system. The forces are the continuous growth of power demand, the engineering response to system failures, and the upgrade of generator capacity. This model suggests that there is a real cause of blackouts in the electric power system beyond the random event that triggers them. This cause is the long-term forces that drive the evolution of the power system towards a critical point.

P33 Trapping heavy particles in open flows

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The advection dynamics of aerosols is relevant in a variety of physical contexts, including astrophysical, atmospheric and environmental research. Previous studies are consistent with the assumption that such heavy particles always escape in open chaotic advection. Here I will show that a different behavior is possible. We have analyzed the dynamics of aerosols both in the absence and presence of gravitational effects, and both when the dynamics of the fluid particles is hyperbolic and nonhyperbolic. Permanent trapping of aerosols much heavier than the advecting fluid is shown to occur in all these cases. In a rather counter-intuitive fashion, we observe that this phenomenon is determined by a process in which the aerosols are continuously scattered by vortices of the underlying flow.

Reference: R. D. Vilela and A. E. Motter, Can aerosols be trapped in open flows? arXiv:0706.1336v1 [nlin.CD], Phys. Rev. Lett. (in press).

P34 Stochastisity and periodically rejimes in three dimensional Volterra-Lotka models

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We are investigated Periodically and Stochastisity rejimes and its bifurcations in three dimensional Volterra-Lotka Models of predator-prey systems.

P35 How well can one resolve the state space of a chaotic flow?

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All physical systems are affected by some noise, which limits the resolution that can be attained in partitioning their state space. For chaotic, locally hyperbolic flows, the resolution depends on the interplay of the local stretching/contraction and the smearing due to noise. Our goal is to determine the finest possible partition of the state space for a given hyperbolic dynamical system and a given additive white noise of specified strength. We test these ideas on two models: the “skew Ulam” map and the Lozi attractor. In both cases we compute the local eigenfunctions of the Fokker-Planck evolution operator in the neighborhood of each periodic point. The supports of such eigenfunctions cover the state space by a finite tiling, which is our optimal partition.

The Fokker-Planck evolution operator is then represented by a finite Markov graph, which is used to determine the escape rate of the noisy attractor, as a test for the validity of our method. The result is compared with what obtained by matrix representation of the same evolution operator.

P36 Parameter space study of an ultra-high frequency chaotic circuit with delayed feedback

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We report an experimental study on the chaotic dynamics of a delayed feedback system. Our device generates ultra-high frequency (UHF) chaotic dynamics and consists of a transistor-based nonlinearity, commercially available amplifiers and a radio-frequency transmission line for delayed feedback. We explore the parameter space of the system, studying the route to chaos beyond the first Hopf bifurcation. For some cases, the route to chaos is through periodic orbits, which transition to quasi-periodic before entering chaos. For some other parameters, the dynamics transition to chaos apparently from periodic behavior directly. The dynamics of the system is sensitive to the feedback delay time.

P37 State space geometry of a spatio-temporally chaotic Kuramoto-Sivashinsky flow

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The continuous and discrete symmetries of the Kuramoto-Sivashinsky system restricted to a spatially periodic domain play a prominent role in shaping the invariant sets of its spatiotemporally chaotic dynamics. The continuous spatial translation symmetry leads to relative equilibria (traveling wave) and relative periodic orbit solutions. The discrete symmetries lead to existence of equilibria and periodic orbit solutions, induce decomposition of state space into orthogonal invariant subspaces, and enforce certain structurally stable heteroclinic connections between equilibria. We show, on example of a particular small-cell Kuramoto-Sivashinsky system, how the geometry of its dynamical state space is organized by a rigid 'cage' built by heteroclinic connections between equilibria, and demonstrate the preponderance of unstable relative periodic orbits and their likely role as the skeleton underpinning spatiotemporal turbulence in systems with continuous symmetries. We also offer novel visualizations of the high-dimensional Kuramoto-Sivashinsky state space flow through projections onto low-dimensional, PDE representation independent, dynamically invariant intrinsic coordinate frames, as well as in terms of the physical, symmetry invariant energy transfer rates.

P38 Stepwise algorithm for phase singularity detection and phase singularity density map creation

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Phase space analysis applied to fluorescent images of cardiac transmembrane electrical activity has offered a unique perspective into cardiac fibrillatory behavior. There are many different algorithms and associated parameters for phase map generation, detection of phase singularities (or wave breaks), and creation of phase singularity density maps. We have developed a completely automated algorithm that can be used to detect phase singularities efficiently and subsequently create singularity density maps in a series of steps from the raw data. Our algorithm is based on the well known and widely accepted time-embedded delay method of computing phase. Our algorithm eliminates some of the typical problems encountered such as edge effects and choice of origin. Results from real experimental fibrillation data

show the robustness and effectiveness of our algorithm. The algorithm was also tested on a notoriously difficult data set in which areas of the heart were activating at different rates.

P39 Steady states and traveling waves of moderate Re plane Couette flow

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We survey known equilibria and relative equilibria of plane Couette flow at moderate Reynolds numbers and present several new such states as well. These are presented in a dynamical, 10^5-dimensional state-space representation to better aid in visualization of their unstable manifolds and relationships in state-space. We then study heteroclinic connections between these states and examine how they change as Reynolds number and spanwise period are varied.

P40 Bifurcations induced by drug diffusion into spontaneously beating aggregates of embryonic chick heart cells

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A standard paradigm for studying physical and biological systems is to systematically analyze the bifurcations in dynamics as a function of the value of a control parameter. Our interest in such problems arises from medical applications in which drugs can lead to the desired suppression of pathological rhythms or, at times, the unwanted induction of abnormal, dangerous rhythms. Analysis of the bifurcations induced by drugs necessarily requires an understanding of the role of diffusion and noise in spatially extended nonlinear systems. In this work we study the dynamics observed following addition of a drug that blocks potassium channels to spontaneously beating aggregates of chick heart cells. The results are monitored by observing the motion of the agrregates following addition of the drug. We observe complex bifurcations of dynamics over time. A stochastic, partial differential equation modeling the ionic processes in these cells captures some of the observed dynamics. These results pose challenges for theoretical interpretation and underscore the delicate problems associated with developing and testing drugs.