DY 10: Nonlinear Dynamics I

Time: Tuesday 14:00–16:15 Location: H46

DY 10.1 Tue 14:00 H46

Zero lag synchronization of a chaotic system with time delayed couplings — •Anja Englert and Wolfgang Kinzel — Institut für Theoretische Physik, Universität Würzburg, 97074 Würzburg

Zero-lag synchronization (ZLS) without self-feedback or adding a relay unit is demonstrated in an experiment of two mutually coupled chaotic semiconductor lasers. The mechanism is based on two mutual coupling delay times with certain integer ratios, where for a single mutual delay time ZLS cannot be achieved. This mechanism is also found for mutually coupled chaotic maps where its stability is analyzed using the Schur Cohn theorem for the roots of polynomials. The symmetry of the polynomials allows only specific integer ratios for ZLS. In addition a general argument for ZLS with several mutual coupling delay times is presented. This work was done in collaboration with Y. Aviad, M. Butkovski, I. Kanter, I. Reidler, M. Rosenbluh and M. Zigzag from Department of Physics, Bar-Ilan University, Israel. Paper to be published.

DY 10.2 Tue 14:15 H46

Distributed vs Fixed Delay in a System of Coupled Phase Oscillators — •Lucas Wetzel[1], Saúl Ares[1], Luis G. Morelli[2], Andrew C. Oates[2], and Frank Jülicher[1] — [1]Max Planck Institute for the Physics of Complex Systems — [2]Max Planck Institute of Molecular Cell Biology and Genetics

Systems of coupled oscillators with delay in the coupling are important for several physical, chemical, engineering, and biological phenomena. In cellular systems, such as the vertebrate segmentation clock, fluctuations in gene expression and transport of macromolecules introduce a variability in the time delay associated with cell to cell communication. In order to account for such variability, we consider the effects of distributed delays.

We study systems of phase oscillators with different coupling topologies, introducing a delay distribution that describes the contributions to the coupling arising from different past times. Surprisingly, our calculations show that for an arbitrary coupling topology where each oscillator is identical and coupled to the same number of oscillators within the system, the frequency of the fully synchronized states as well as the stability of such solutions only depend on the first moment of the distribution. The system is thus closely related to one with a fixed delay whose value equals the first moment of the distribution.

DY 10.3 Tue 14:30 H46

Pulsed time delayed feedback and the anticipation of chaotic dynamics — •Thomas Jüngling[1], Hartmut Benner[1], and Wolfram Just[2] — [1]Institute for Condensed Matter Physics, TU Darmstadt, Germany — [2]School of Mathematical Sciences, Queen Mary / University of London, United Kingdom

Feedback with time delay is widely known for its ability to induce an infinite number of dynamical degrees of freedom. Such an aspect normally prevents one from a deeper understanding of the relevant phase space structures. We present an example of a system with a pulsed delay term such that an infinite number of delay modes freezes out, with the dynamics taking place on a finite-dimensional subspace. Moreover, such a generic mechanism can be used to identify types of modulated time-delayed feedbacks which are able to induce superstable behaviour. We apply this concept for the purpose of anticipating chaotic synchronisation. The stability of synchronised states can be improved considerably by pulsed feedback. The validity of the theoretical considerations and their relevance for applications is demonstrated by experimental results as well.

DY 10.4 Tue 14:45 H46

Double entropic stochastic resonance — P. Sekhar Burada[1,2], •Gerhard Schmid[2], and Peter Hänggi[2] — [1]MPI for the Physics of Complex Systems, Dresden, Germany — [2]University of Augsburg, Augsburg, Germany

We demonstrate the appearance of a purely entropic stochastic resonance (ESR). This new phenomena is occurring in geometrically confined systems [1,2], where the irregular boundaries cause entropic barriers. The interplay between a periodic input signal, a constant bias and intrinsic thermal noise, leads to a resonant ESR phenomenon in which feeble signals become amplified. This new phenomenon is characterized by the presence of two peaks in the spectral amplification at corresponding optimal values of the noise strength. The nature of ESR, occurring when the origin of the barrier is entropic rather than energetic, offers new perspectives for novel investigations and potential applications. ESR by itself presents yet another case where one constructively can harvest noise in driven nonequilibrium systems.

[1] P. S. Burada, G. Schmid, D. Reguera, M. H. Vainstein, J. M. Rubi, and P. Hänggi, Phys. Rev. Lett. **101**, 130602 (2008).
[2] P. S. Burada, G. Schmid, D. Reguera, J. M. Rubi, and P. Hänggi, EPL **87**, 50003 (2009).

DY 10.5 Tue 15:00 H46

Periodic orbits in the sliding of graphite flakes — •Astrid S. de Wijn, Claudio Fusco, and Annalisa Fasolino — Institute for Molecules and Materials, Radboud University Nijmegen, Heyendaalseweg 135, 6525 AJ Nijmegen, the Netherlands

Theoretical consideratons show that the sliding of an atomic layer weakly interacting with an incommensurate periodic substrate can occur with vanishingly low friction. Indeed, extremely low friction has been observed experimentally in several systems and this effect has been named superlubricity. However, there is recent evidence that the incommensurate superlubric state is destroyed by rotation of the sliding flake [2], leading to a commensurate state with high friction.

In this work, we study the dynamics of finite rigid graphite flakes on a graphite surface. In numerical simulations, we find that after an initial short period, the flake either rotates and locks into a commensurate orientation or it remains incommensurate and slides with extremely low friction. We construct a simple model system which captures the essential dynamics, and for which the stability can be investigate d analytically. We show that for a realistic system periodic orbits exist that correspond to the commensurate and incommensurate states and that they may be stable. We investigate the robustness of the incommensurate superlubric state against parameters such as sliding velocity and temperature.

[1] M. Dienwiebel et al., Phys. Rev. Lett. **92**, 126101 (2006).
[2] A.E. Filippov et al., Phys. Rev. Lett. **100**, 046102 (2008).

DY 10.6 Tue 15:15 H46

Scaling properties of bred- and Lyapunov vectors — •Sarah Hallerberg[1], Juan M. Lopez[2], Diego Pazo[2], and Miguel A. Rodriguez[2] — [1]Institut für Physik, TU Chemnitz — [2]Instituto de Fisica de Cantabria (IFCA), CSIC-Universidad de Cantabria, Santander

It has been demonstrated that the spatio-temporal dynamics of characteristic Lyapunov vectors in spatially extended chaotic systems can be related to properties of scale invariant growing surfaces [1]. We study now, whether similar scaling properties, can also be observed for bred vectors. Moreover we propose a new method to estimate Lyapunov exponents corresponding to the most expanding directions using bred vectors [2]. More precisely, the scaling properties of the perturbations allow us to associate a bred vector of a given amplitude to a specific Lyapunov vector within the first ten percent of the Lyapunov spectrum. In this contribution we extend the results obtained in previous studies for the Lorenz'96 model [3] to applications in a minimalistic climate model [4].

References: [1] D. Pazo et al. (2008) [2] E. Kalnay et al. (2002) [3] E. N. Lorenz (1998) [4] V. Lucarini et al. (2007)

DY 10.7 Tue 15:30 H46

Recurrence networks: A novel paradigm for nonlinear time series analysis — •Reik V. Donner[1,2,3], Yong Zou[3], Jonathan F. Donges[3,4], Norbert Marwan[3], and Jürgen Kurths[3,4] — [1]Max Planck Institute for Physics of Complex Systems, Dresden, Germany — [2]Institute for Transport and Economics, Dresden University of Technology, Germany — [3]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [4]Department of Physics, Humboldt University of Berlin, Germany

We present a novel approach for analysing structural properties of dynamical systems based on time series. Starting from the concept of recurrences in phase space, the recurrence matrix of a time series is interpreted as the adjacency matrix of an associated complex network which links different points in time if the evolution of the considered states is very similar. A critical comparison of these recurrence networks with similar existing techniques is presented, revealing strong conceptual benefits of the new approach which can be considered as a unifying framework for transforming time series into complex networks that also includes other methods as special cases.

We demonstrate the presence of fundamental relationships between the topological properties of recurrence networks and the statistical properties of the phase space density of the underlying dynamical system. Hence, the network description yields new quantitative characteristics of the dynamical complexity of a time series, which substantially complement existing measures of recurrence quantification analysis.

DY 10.8 Tue 15:45 H46

Dämpfung einer schwingenden Masse durch ein freies Reibelement — •Alexander Maria Többens — DLR Deutsches Zentrum für Luft- und Raumfahrt, Institut für Aeroelastik, Göttingen, Deutschland — Drittes Physikalisches Institut, Göttingen, Deutschland

Der Vortrag behandelt die Dynamik eines eindimensionalen nichtlinearen Oszillators, bestehend auf einer horizontal schwingenden, periodisch getriebenen Masse und einer locker auf dieser aufliegenden zweiten Masse. Beide Körper wechselwirken über die an der Kontaktfläche auftretende trockene Reibung. Befindet die aufliegende Masse sich relativ zur schwingenden Masse in Bewegung, entzieht sie der Schwingung Energie, wirkt also als Dämpfer.

Der Oszillator dient als einfaches Modell für Vorgänge in Flugzeugtriebwerken, wo solche frei aufliegenden Reibelemente eingesetzt werden, um durch Luftkräfte angeregte Schwingungen der Rotorblätter zu dämpfen. Vorgestellt werden die mathematische Modellierung sowie numerische Untersuchungen der vielfältigen Dynamik des Systems.

DY 10.9 Tue 16:00 H46

Long lived chaotic transients in open Hamiltonian systems — •Tamás Kovács — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We focus in this work on the finite time chaotic behavior in low dimensional dynamical systems, especially, the simple configurations in astrodynamics. Our numerical results show the existence of an invariant fractal object, the well known chaotic saddle, in the phase space that is responsible for the chaotic transients. We present several quantitative properties (escape rate, fractal dimension, Lyapunov exponent) of the saddle and compare them with the quantities in the permanently chaotic regime. Finally, the stickiness affect appearing close to KAM tori in Hamiltonian systems will be discussed.