DY 9: Nonlinear dynamics, synchronization and chaos II

Time: Tuesday 10:15–12:45 Location: ZEU 255

DY 9.1 Tue 10:15 ZEU 255

Noise and timing in cellular automata — •Konstantin Klemm — Bioinformatics, Leipzig University, Germany

Cellular automata (CA) form a broad class of models for discrete complex dynamics as they produce a wealth of non-trivial spatio-temporal patterns with simple rules of interaction. The complex behaviour is observed in deterministic CA with step-wise synchronous update. However, long-term and long-range correlations are suppressed when switching to random asynchronous update which acts as a source of strong noise.

Here I consider CA under weak but non-vanishing noise, implemented as small fluctuations of the time a cell needs to respond to a changing input. I find that stability under these fluctuations strongly varies across CA rules. In Conway's Game of Life, most dynamic elements such as blinkers and gliders are unstable. Also Wolfram's elementary CA rule 110 is highly unstable, while the linear rule 150 and the chaotic rule 22 are examples of stable rules. These findings restrict the candidate set of mechanisms underlying complex dynamics. In the presence of noise, only stable CA rules are eligible as models of reproducible pattern generation.

DY 9.2 Tue 10:30 ZEU 255

Canards and gluing dynamics in muscle sarcomeres. — •Stefan Günther and Karsten Kruse — Saarland University, Saarbrücken

Sarcomeres, the elementary force generating elements of muscles, are able to oscillate spontaneously [1]. In a chain of sarcomeres, these oscillations can lead to traveling waves. Here we present a microscopic model for sarcomeres that takes into account the action of molecular motors and of elastic elements. The model can generate oscillations due to a Hopf-bifurcation. In addition, we find canard explosions, which are strong deformations of a limit cycle close to a Hopf-bifurcation, which account for wave generation. Beyond we find gluing bifurcations that result from the fusion of two oscillatory solutions having its origin in a varying number of molecular motors that participate in sarcomere contraction.

[1] Yasuda, Shindo, and Ishiwata, Biophys. J. 70 (1996)

DY 9.3 Tue 10:45 ZEU 255

Pattern Formation During Deformation of a Confined Viscoelastic Layer: From a Viscous Liquid to a Soft Elastic Solid. — •Julia Nase[1,2], Anke Lindner[1], and Costantino Creton[2] — [1]PMMH-ESPCI, Paris, France — [2]PPMD-ESPCI, Paris, France

We study pattern formation during tensile deformation of confined viscoelastic layers. The use of a model system (PDMS with different degrees of crosslinking) allows us to go continuously from a viscous liquid to an elastic solid. We observe two distinct regimes of fingering instabilities: a regime called "elastic" with interfacial crack propagation where the fingering wavelength only scales with the film thickness, and a bulk regime called "viscoelastic" where the fingering instability shows a Saffman-Taylor-like behaviour. We find good quantitative agreement with theory in both cases and present a reduced parameter describing the transition between the two regimes and allowing to predict the observed patterns over the whole range of viscoelastic properties.

DY 9.4 Tue 11:00 ZEU 255

Atrial fibrillation induced by interference of regular wave fronts with fronts emanating from a spiral wave — •Claudia Hamann, Mario Einax, and Philipp Maass — Institut für Physik, Technische Universität Ilmenau, Germany

We investigate the interference of a stable spiral wave in the left atrium with regular paced waves in the right atrium as generating mechanism of atrial fibrillation on the basis of the FitzHugh-Nagumo model. We show that this interference scenario is a possible cause of fibrillation in the right atrium. A high pacing rate can yield an irregular, fibrillatory state and is seen as a key factor for the occurrence of fibrillation episodes [1].

[1] C. Hamann, diploma thesis, Technische Universität Ilmenau, 2008

DY 9.5 Tue 11:15 ZEU 255

Computing by Switching? Heteroclinic Bifurcation in Spiking Neural Networks — •Fabio Schittler-Neves, Christoph Kirst, Andreas Sorge, and Marc Timme — Network Dynamics Group, MPI for Dynamics and Self-Organization, Göttingen, Germany

Networks of spiking neurons may often exhibit saddle periodic orbits that are heteroclinically connected among each other. For fast interaction responses, these systems may show heteroclinically connected unstable attractors [1-3]. Here we show that pulse-coupled (spiking) systems exhibit an analog of heteroclinic bifurcation that has both discrete and continuous parts [4]. On this basis, we demonstrate how input signals may be encoded by spiking neural networks in a novel way.

[1] M. Timme et al., Phys. Rev. Lett. 89:154105 (2002)
[2] P. Ashwin and M. Timme, Nonlinearity 18:2035-2060 (2005)
[3] P. Ashwin and M. Timme, Nature 436:36-37 (2005)
[4] C. Kirst and M. Timme, http://arxiv.org/abs/0709.3432v1, Phys. Rev. E, Rapid Communications (accepted)

15 min. break.

DY 9.6 Tue 11:45 ZEU 255

Coupling effects of time-delayed feedback for the synchronization of neural dynamics — •Philipp Hövel[1], Sarang A. Shah[2], Markus A. Dahlem[1], and Eckehard Schöll[1] — [1]Institut f. Theo. Physik, Sekr. EW 7-1, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Georgia Institute of Technology, Atlanta, Georgia 30332, USA

We investigate two mutually coupled neural populations modeled by two FitzHugh-Nagumo systems. The subsystems are prepared at parameter values at which no autonomous oscillations occur and each system is subject to its own source of random fluctuations realized by Gaussian white noise. For proper choices of the noise intensities and coupling strength, we find cooperative dynamics such as frequency synchronization and phase synchronization. It was shown by Hauschildt et al. that application of time-delayed feedback, which was originally suggested for deterministic chaos control, is able to influence the cooperative dynamics. We discuss various coupling schemes of the feedback method and investigate the effects of specific realizations, i.e., when the control force is generated form the activator or inhibitor and applied to either component.

DY 9.7 Tue 12:00 ZEU 255

Synchronization of coupled demographic oscillators — •Tobias Galla — Theoretical Physics, School of Physics and Astronomy, The University of Manchester, Manchester M139PL, UK

Demographic oscillators are individual-based systems exhibiting temporal cycles sustained by the stochastic dynamics of the microscopic interacting particles. We here use the example of coupled predator-prey oscillators to show that synchronization to a common frequency can occur between two such systems, even if they oscillate at different frequencies in the absence of coupling. The power spectra of the separate and the coupled systems are computed within a van Kampen expansion in the inverse system size, and it is found that they exhibit two peaks at separate frequencies at low coupling, but that only one peak is present at large enough coupling strength. We further make predictions on the time behaviour of the phases of the two oscillators, and their phase difference, and so confirm the frequency entrainment. Theoretical results are verified convincingly in numerical simulations.

[Reference: Tobias Galla, Synchronization of coupled demographic oscillators, arXiv:0811.3689]

DY 9.8 Tue 12:15 ZEU 255

Synchronization of networks of chaotic units with time-delayed couplings — •Anja Englert[1], Wolfgang Kinzel[1], and Ido Kanter[2] — [1]Institut für Theoretische Physik und Astrophysik, Universitität Würzburg, Germany — [2]Department of Physics, Bar-Ilan University, Ramat-Gan, Israel

A network of chaotic units is investigated where the units are coupled by signals with a transmission delay. It is shown that chaotic trajectories cannot be synchronized if the transmission delay is larger than

the time scales of the isolated units. For several models the master stability function is calculated which determines the maximal delay time for which synchronization is possible.

See: www.physik.uni-wuerzburg.de/?id=2200

DY 9.9 Tue 12:30 ZEU 255

Partial mean conditional recurrences for the identification of indirectionality in model systems — •Yong Zou[1], Marco Thiel[2], Mamen Romano[2], and Juergen Kurths[1,3] — [1]Potsdam Institute for Climate Impact Research, P.O. Box 601203, 14412 Potsdam, Germany — [2]Department of Physics, University of Aberdeen, Aberdeen AB 24 3UE, United Kingdom — [3]Institut for Physik, Humboldt Universität zu Berlin, Newtonstr. 15, 12489 Berlin, Germany

The identification of the coupling directionality from measured time series taking place in a group of interacting components is a non-trivial problem for experimental studies. We propose a method to uncover the coupling configuration by means of recurrence properties. The approach hinges on a generalization of conditional probability of recurrence, which was originally introduced to detect and quantify the weak coupling directionality between two interacting subsystems. Here, we extend this approach to the case of multivariate time series, where the indirect interaction presents. We test our method by considering three coupled Van der Pol oscillators contaminated with normal distributed noise. Furthermore, we extract the correct time delay information contained in the three coupled Lorenz systems. Our results confirm that the proposed method could be used to identify the indirectionality, which shows relevance for experimental time series analysis.