DY 9: Nonlinear dynamics, synchronization and chaos I

Time: Monday 17:00–18:30 Location: MA 004

DY 9.1 Mon 17:00 MA 004

Self-induced oscillations in an optomechanical system — •Clemens Neuenhahn[1,2], Maximilian Ludwig[1,2], Constanze Metzger[3], Alexander Ortlieb[2], Ivan Favero[4], Khaled Karrai[2], and Florian Marquardt[1,2] — [1]Arnold-Sommerfeld Center for Theoretical Physics — [2]Center for Nanoscience and Departement of Physics, Ludwig-Maximilians Universität München, Munich, Germany — [3]Boston University, Electrical and Computer Engineering, Boston, MA 02215, USA — [4]Université Paris Diderot, Laboratoire Matériaux et Phénomènes Quantiques, Bâtiment Condorcet, 75205 Paris CEDEX 13

We have explored the nonlinear dynamics of an optomechanical system consisting of an illuminated Fabry-Perot cavity, one of whose end-mirrors is attached to a vibrating cantilever. Such a system can experience negative light-induced damping and enter a regime of self-induced oscillations. We present a systematic experimental and theoretical study of the ensuing attractor diagram in an experimental setup where the oscillation amplitude becomes large, and the mirror motion is influenced by several optical modes. A theory has been developed that yields detailed quantitative agreement with experimental results. This includes the observation of a regime where two mechanical modes of the cantilever are excited simultaneously.

DY 9.2 Mon 17:15 MA 004

Synchronization and Desynchronization in Chaotic Map Networks — •Mirko Schäfer[1] and Martin Greiner[2] — [1]Frankfurt Institute for Advanced Studies (FIAS), Ruth-Moufang-Straße 1, 60438 Frankfurt am Main, Germany — [2]Corporate Technology, Information Communications, Siemens AG, 81730 München

We study the dynamics of coupled Tchebycheff maps on networks as a function of the coupling parameter. Various network topologies are considered. We are interested in a characterization of the respective coupling regimes where maximum synchronization or desynchronization is reached. The latter case may have some relevance to the standard model of elementary particles.

DY 9.3 Mon 17:30 MA 004

Multivariate Characterisation of Spatially Heterogeneous Phase Synchronisation — •Reik Donner — TU Dresden, Andreas-Schubert-Str. 23, 01062 Dresden, Germany

Over the last decades, the emergence of synchronisation phenomena in complex networks has attracted considerable interest. In particular, phase synchronisation phenomena of coupled oscillators have be observed in a variety of systems. In this contribution, we discuss how phase synchronisation can be properly detected in the case of multi-component systems. Whereas the traditional approach has exclusively considered averages of bivariate synchronisation measures, in the recent years, different approaches to synchronisation cluster analysis have been proposed. Some of these methods are reviewed and thoroughly compared. In particular, we discuss the potential importance of different eigenvalue statistics obtained from matrices of pairwise phase coherence measures for the characterisation of spatially heterogeneous or clustered phase synchronisation. Our results are illustrated for networks of phase oscillators as well as the problem of self-organised material flows on networks.

DY 9.4 Mon 17:45 MA 004

Modelling of oscillatory phase separation of binary mixtures under continuous cooling — •Yumino Hayase, Günter K. Auernhammer, and Doris Vollmer — Max Planck Institute for Polymer Research, Mainz, Germany

We investigate the phase separation of binary mixtures under continuously ramping temperature using the Cahn-Hilliard equation including gravity. Our model is motivated by the experimental observation that for a broad range of composition and cooling rates binary mixtures may show pronounced oscillation in the turbidity, i.e. the transition to the biphasic state happens via a cascade of nucleation waves. The number of oscillations and their frequency depend on the choice of the components and the cooling rate [1]. Typically either the upper or the lower phase oscillates and hardly both. To understand the mechanism of oscillation instability we investigate the kinetics of phase separation under continuous cooling using the Cahn-Hilliard equation, the most widely studied model equation for the description of phase separation. To account for sedimentation we have added a mechanism to the C-H equation taking gravity into account. Numerically, we observe oscillatory wave of droplet formation. Depending on the composition and shape of the phase diagram, either both or only one phase oscillates. The oscillation period and the cooling rate have a power law relation. Experimental results support the numerical results very well.

[1] G.K. Auernhammer, D. Vollmer, and J. Vollmer, J. Chem. Phys., 123, 134511 (2005)

DY 9.5 Mon 18:00 MA 004

From Unstable Attractors to Heteroclinic Switching — •Christoph Kirst[1,2,3,4] and Marc Timme[1,2] — [1]Network Dynamics Group, Max Planck Institute for Dynamics and Self-Organization (MPIDS) — [2]Bernstein Center for Computational Neuroscience (BCCN) Göttingen, 37073 Göttingen, Germany — [3]Fakultät für Physik, Georg-August-Universität Göttingen, Germany — [4]DAMTP, Centre for Mathematical Sciences, Cambridge University, Cambridge CB3 0WA, UK

We report the first example of a dynamical system that naturally exhibits two unstable (Milnor) attractors that are completely enclosed by each others basin volume. This counter-intuitive phenomenon occurs in networks of pulse-coupled oscillators with delayed interactions. We analytically and numerically investigate this phenomenon and clarify the mechanism underlying it [1]: Upon continuously removing the non-invertibility of the system, the set of two unstable attractors becomes a set of two non-attracting saddle states that are heteroclinically connected to each other. This transition from a network of unstable attractors to a heteroclinic cycle constitutes a new type of bifurcation in dynamical systems.

[1] C. Kirst and M. Timme, arXiv:0709.3432 (2007)

DY 9.6 Mon 18:15 MA 004

Relaxation oscillations and chaos in the torsional Quincke pendulum — •Michael Zaks[1] and Mark Shliomis[2] — [1]Institut für Physik, Humboldt-Universität zu Berlin — [2]Ben-Gurion University, Beer Sheva, Israel

Let a constant electric field act upon an insulating body suspended into a liquid with low conductivity. If the field is sufficiently strong, the body starts to rotate; this phenomenon is known under the name of Quincke effect. Dynamics of this torsional motion has been recently shown to obey the Lorenz equations, provided the elasticity of suspension is discarded: depending on the field strength, the Quincke rotor exhibits stationary and chaotic rotations. We take elasticity into account and demonstrate that in a certain range of the field intensity the rotor should perform relaxational oscillations with large amplitude. Explicit expressions relate the amplitude and period of oscillations to physical parameters of the problem: intensity of the field, viscosity of the liquid and elasticity of the suspension. In stronger fields the regime of large-scale relaxational oscillations breaks down abruptly and is replaced by minor erratic fluctuations of the pendulum. We explain this transition in terms of the global bifurcations in the Lorenz equations.