SOE 10: Nonlinear Dynamics 1: Synchronization and Chaos (joint session DY/SOE)

Time: Tuesday 11:15–12:45 Location: H19

SOE 10.1 Tue 11:15 H19

Stable Poisson chimeras in networks of two subpopulations — •Seungjae Lee and Katharina Krischer — Technical University of Munich, Garching, Germany

In this talk, we introduce recent results on dynamical and spectral properties of chimeras in two-population network based on Kuramoto order parameter and Lyapunov stability analysis. In particular, we address two qualitatively different dynamics of incoherent oscillator populations according to the given initial conditions, and which led to the classification of Poisson and non-Poisson chimera states. We numerically calculate the Lyapunov exponents and covariant Lyapunov vectors to determine the spectral properties of the chimera states, and then expound the classification of the Lyapunov exponents. Our stability analysis also confirms that the chimera states of Kuramoto-Sakaguchi phase oscillators in two-population networks are neutrally stable in many directions. Furthermore, we demonstrate that two *perturbations* of the phase model that reflect more realistic situations render Poisson chimeras stable. These models consider a nonlocal intra-population network and Stuart-Landau planar oscillators with amplitude degrees of freedom, respectively. Both these 'perturbations' might be considered a heterogeneity of the phase model and give rise to an asymptotically attracting Poisson chimera in two-population networks.

SOE 10.2 Tue 11:30 H19

On rational reactions - and other ones - of overloaded magnetic gears — •Ingo Rehberg and Stefan Hartung — Universität Bayreuth

Experiments exploring the coupling of two rotating spherical magnets reveal a cogging-free coupling for two specific angles between the input and output rotation axes. The striking difference between these two phase-locked modes of operation is the reversed sense of rotation of the driven magnet. For other angles, the cogging leads to a more complex dynamical behaviour. The experimental results can be understood by a mathematical model based on pure dipole-dipole interaction, with the addition of adequate friction terms [1].

Like all magnetic couplings, the setup contains intrinsic overload protection. The dynamic answer of the gear with cogging to an overload shows a plethora of modes of the driven magnet.

[1] Dynamics of a magnetic gear with two cogging-free operation modes, Stefan Hartung & Ingo Rehberg, Archive of Applied Mechanics 91, 1423-1435 (2021).

SOE 10.3 Tue 11:45 H19

Heteroclinic units acting as pacemakers: Entrained dynamics for cognitive processes — •Bhumika Thakur and Hildegard Meyer-Ortmanns — School of Science, Jacobs University Bremen, Campus Ring 1, 28759 Bremen, Germany

Heteroclinic dynamics is a suitable framework for describing transient and reproducible dynamics such as cognitive processes in the brain. We demonstrate how heteroclinic units can act as pacemakers to entrain larger sets of units from a resting state to hierarchical heteroclinic motion that is able to describe fast oscillations modulated by slow oscillations, features which are observed in brain dynamics. The entrainment range depends on the type of coupling, the spatial location of the pacemaker and the individual bifurcation parameters of the pacemaker and the driven units. Noise as well as a small back-coupling to the pacemaker facilitate synchronization. Units can be synchronously entrained to different temporal patterns, depending on the selected path in the hierarchical heteroclinic network. These locally generated temporal sequences of information items can be transferred over a spatial grid by entrainment to the pacemaker dynamics. Such spatiotemporal patterns are believed to code information in brain dynamics. Depending on the number and location of pacemakers on two-dimensional grids, synchronization can be maintained in the presence of a large number of resting state units and mediated via target waves when the pacemakers are concentrated to a small area of such grids. In view of brain dynamics, our results indicate a possibly ample repertoire for coding information in temporal patterns.

SOE 10.4 Tue 12:00 H19

Suppression of quasiperiodicity in circle maps with quenched disorder — •David Müller-Bender[1], Johann Luca Kastner[1], and Günter Radons[1,2] — [1]Institute of Physics, Chemnitz University of Technology, 09107 Chemnitz, Germany — [2]Institute of Mechatronics, 09126 Chemnitz, Germany

We show that introducing quenched disorder into a circle map leads to the suppression of quasiperiodic behavior in the limit of large system sizes. Specifically, for most parameters the fraction of disorder realizations showing quasiperiodicity decreases with the system size and eventually vanishes in the limit of infinite size, where almost all realizations show mode-locking. Consequently, in this limit, and in strong contrast to standard circle maps, almost the whole parameter space corresponding to invertible dynamics consists of Arnold tongues.

Details can be found in the preprint D. Müller-Bender, J. L. Kastner, and G. Radons, Suppression of quasiperiodicity in circle maps with quenched disorder, arXiv:2204.09392 [nlin.cd] (2022).

SOE 10.5 Tue 12:15 H19

Reservoir Computing and Nonlinear Dynamics — •Ulrich Parlitz — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — Institute for the Dynamics of Complex Systems, Georg-August-Universität Göttingen, Göttingen, Germany

We discuss the interrelation between reservoir computing (RC) and nonlinear dynamics (NLD). On the one hand, the performance of RC can be characterized and improved by concepts from NLD such as generalized synchronization and delay embedding. On the other hand, RC can be used to predict and control dynamical systems, including hybrid architectures that employ physically informed machine learning. Various aspects of this mutual relationship between RC and NLD are illustrated using low-dimensional and spatially extended chaotic dynamical systems.

SOE 10.6 Tue 12:30 H19

Chameleon attractors in deterministic and stochastic Lorenz-63 systems — •Reik V. Donner[1,2], Tommaso Alberti[3], and Davide Faranda[4] — [1]Hochschule Magdeburg-Stendal, Magdeburg, Germany — [2]Potsdam Institute for Climate Impact Research, Potsdam, Germany — [3]National Institute for Astrophysics, Rome, Italy — [4]LSCE, Université Paris-Saclay, Gif-sur-Yvette, France

The dynamical chaacteristics of a trajectory on a chaotic or stochastic attractor undergo marked changes when successively eliminating the low-frequency variability components and focusing on the fast fluctuations only, motivating the new concept of Chameleon attractors. Here, we study the time scale dependent instantaneous and average fractal characteristics of partial sums of dynamical modes identified by means of empirical mode decomposition for the Lorenz-63 system and two stochastic versions thereof with additive and multiplicative noise as obtained by exploiting recurrences in phase space using extreme value theory. While the average fractal dimensions converge to the expected values as more and more low-frequency modes are included, we find an excess dimension larger than 3 for higher frequency modes below the Lyapunov time scale resulting from the stochastic components.