SOE 22: Focus Session: Controlling Complex Networks in Nature and Engineering (joint DY / SOE / BP)

The control of complex dynamical networks is of great current interest, especially in the light of various applications in nature and engineering, e.g., brain, genetic networks, communication, transport and supply networks, power grids. Important issues are the control of networks with complex topologies and heterogeneous components, in particular by making small local perturbations to steer the system to a desired target state or stabilize a desired state.

Organized by Eckehard Schöll and Anna Zakharova

Time: Friday 9:30–12:30 Location: ZEU 160

Invited Talk SOE 22.1 Fri 9:30 ZEU 160

Influence of network topology on spreading of epileptic seizure — •Simona Olmi[1], Spase Petkoski[2], Fabrice Bartolomei[2,3], Maxime Guye[4], and Viktor Jirsa[2] — [1]Weierstrass Institute, Berlin, Germany — [2]Aix-Marseille Univ, Inserm, Institut de Neurosciences des Systémes, Marseille, France — [3]Assistance Publique, Hôpitaux de Marseille, Hôpital de la Timone, Service de Neurophysiologie Clinique, Marseille, France — [4]Faculté de Médecine de la Timone, Centre de Résonance Magnétique et Biologique et Médicale, Medical School of Marseille, Aix-Marseille Université, Marseille, France

In partial epilepsy, seizures originate in a local network, the so-called epileptogenic zone, before recruiting other close or distant brain regions. Correctly delineating the epileptogenic and the propagation zone is essential for successful resective surgery. In particular the stereotaxic EEG (SEEG) is used to edge the zone to resect. However the propagation pathways of epileptic seizures are still largely unknown. Using a specific dynamical model for epilepsy [1], we then predict the recruitment network given the seizure origins and we try to understand the role played by the topology in constraining the recruitment process. The identification of the minimal number of connections that allows the seizure to propagate, via the application of linear stability analysis, and the choice of the optimal set of links to be cut in order to stop seizure propagation might reveal an approach to improve the success rate of epilepsy surgery. [1] Jirsa VK, Stacey WC, Quilichini PP, Ivanov AI, Bernard C (2014) 137:2210-2230.

Invited Talk SOE 22.2 Fri 10:00 ZEU 160

Chimera patterns induced by complex connectivity in Leaky Integrate-and-Fire Networks — •Astero Provata[1], Nefeli Tsigkri-DeSmedt[1], Johanne Hizanidis[1], Philipp Hoevel[2], and Eckehard Schoell[2] — [1]Intitute of Nanoscience and Nanotechnology, National Center for Scientific Research "Demokritos", 15310 Athens, Greece — [2]Institut fur Theoretische Physik, Technische Universitaet Berlin, Hardenbergstrasse 36, 10623 Berlin, Germany a

We study synchronization patterns in ring networks of Leaky Integrate-and-Fire(LIF) oscillators under different connectivity schemes. Earlier studies have demonstrated the formation of chimera and multichimera states in LIF networks with nonlocal connectivity and specific ranges of parameters. Because in natural networks the connectivity takes complex schemes we investigate here the modifications in the form of the chimera states under: a) reflecting connectivity and b) diagonal connectivity. In case a) we show numerically that reflecting connectivity induces a novel chimera pattern in which near-threshold elements coexist with oscillating ones. The oscillating elements form arch-shaped mean phase velocity profiles while the potentials of the near-threshold elements never drop to the resting state. In case b) the diagonal connectivity induces multichimera states whose mean phase velocity profile changes its multiplicity as the coupling constant varies, while regimes of classic multichimera states are separated by synchronous regimes.The new synchronization patterns demonstrate the influence of complex connectivity in network synchronization.

SOE 22.3 Fri 10:30 ZEU 160

Coherence-Resonance Chimeras in a Neural Network — •Anna Zakharova[1], Nadezhda Semenova[2], Vadim Anishchenko[2], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Department of Physics, Saratov State University, Astrakhanskaya street 83, 410012 Saratov, Russia

We show that chimera patterns can be induced by noise in nonlocally coupled neural networks in the excitable regime. In contrast to classical chimeras, occurring in noise-free oscillatory networks, they have features of two phenomena: coherence resonance and chimera states. Therefore, we call them coherence-resonance chimeras [1]. These patterns demonstrate the constructive role of noise and appear for intermediate values of noise intensity, which is a characteristic feature of coherence resonance. In the coherence-resonance chimera state a neural network of identical elements splits into two coexisting domains with different behavior: spatially coherent and spatially incoherent, a typical property of chimera states. Moreover, these noise-induced chimera states are characterized by alternating behavior: coherent and incoherent domains switch periodically their location. We show that this alternating switching can be explained by analyzing the coupling functions.

[1] N. Semenova, A. Zakharova, V. Anishchenko, E. Schöll, Coherence-resonance chimeras in a network of excitable elements, Phys. Rev. Lett. 117, 014102 (2016)

SOE 22.4 Fri 10:45 ZEU 160

Self-controlled latching dynamics in simple models with attractor-ruins — •Diemut Regel and Marc Timme — Network Dynamics, MPI for Dynamics and Self-Organization, 37077 Goettingen, Germany

Standard models of natural computation commonly exhibit attractors as their core concept, with convergence dynamics towards them viewed as the completion of a computational task, e.g. the recognition of an object or the processing of a piece of information [1]. Higher cognitive activities such as free association have been proposed to be representable by latching dynamics [2], a repeated switching between representative system states by dynamical parameter drifting that is intrinsically controlled by the system itself. Yet, how such latching might be achieved and which mechanism may cause latching in dynamical systems is not well understood. Here we propose simple models of latching dynamics and reveal fundamental mechanisms of their self-control options.

[1] J.J. Hopfield, Proc. Natl. Acad. Sci. (1982).
[2] A Treves, Cogn. Neuropsychol. (2005).

SOE 22.5 Fri 11:00 ZEU 160

Interaction Control to Synchronize Non-synchronizable Networks — •Malte Schröder[1], Aditya Tandon[2], Sagar Chakraborty[2], Dirk Witthaut[3], Jan Nagler[4], and Marc Timme[1] — [1]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany — [2]Department of Physics, Indian Institute of Technology Kanpur, Kanpur, Uttar Pradesh 208016, India — [3]Forschungszentrum Jülich, Institute for Energy and Climate Research (IEK-STE), 52428 Jülich, Germany — [4]Computational Physics, IfB, ETH Zurich, 8093 Zurich, Switzerland

Synchronization constitutes one of the most fundamental collective dynamics across networked systems. Whether a system may synchronize depends on the internal unit dynamics as well as the topology and strength of their interactions. For chaotic units with certain interaction topologies synchronization might be impossible across all interaction strengths, meaning that these networks are non-synchronizable.

Here we propose the concept of interaction control, generalizing transient uncoupling, to induce desired collective dynamics in complex networks. Intriguingly, localizing interactions in phase space by a fixed control scheme enables stable synchronization across *all* connected networks regardless of topological constraints. Interaction control may thus ease the design of desired collective dynamics, even without knowledge of the networks exact interaction topology.

15 min break

SOE 22.6 Fri 11:30 ZEU 160

Complex communication in automotive networks — •Christian Pigorsch — BMW AG, Hufelandstraße 1, 80788 München

Different types of automotive networks have been used for the communication in BMW vehicles. For communication across such heterogeneous networks, it is important to ensure stability and robustness, especially for safety related use cases. This is accomplished by evaluating the in-car implementation by means of statistical parameters and comparing the results with the specification. This timing analysis approach, and the questions it introduces, will be illustrated in this talk using several examples. The overall goal of the communication design is optimal utilization of communication resources.

SOE 22.7 Fri 11:45 ZEU 160

On the Impact of Network Topology on Distributed Constraint-Satisfaction Problems — •Henning Blunck[1], Dieter Armbruster[2], Julia Bendul[1], and Marc-Thorsten Hütt[1] — [1]Jacobs University Bremen, Bremen, Germany — [2]Arizona State University, Tempe, AZ, USA

The scheduling of operations to machines is a core logistic challenge with a multitude of applications in our complex industrialized world. As part of the so called "fourth industrial revolution", distributed, agent-based approaches to this problem are receiving renewed attention, with important questions about the design about such systems still unanswered.

In the light of the above, we investigate the more general question how network structure influences the solution performance of distributed constraint-satisfaction problems, here the problem of finding a k-coloring. In particular, we study the impact of “leader”-nodes, nodes introduced specifically to collect and distribute information from large parts of the network.

The results we find shed light on the role of hubs in coordination processes on networks with direct implications not only on long held beliefs in the domain of agent-based production control, but Multi-Agent system design and organization theory.

SOE 22.8 Fri 12:00 ZEU 160

Towards an integrated model for stochastic effects in power system dynamics and control — •Philipp C. Böttcher and David Kleinhans — NEXT ENERGY | EWE Research Centre for Energy Technology, Carl-von-Ossietzky-Straße 15, 26129 Oldenburg

While today’s energy system heavily relies on fossil fuels, the energy systems of tomorrow most likely will be realised with a large share of renewable energies. This will have several advantages, but also introduces highly volatile energy sources without inertia into a system designed for conventional energy sources with large rotating generator masses. To cope with the strongly fluctuating energy resources various aspects of the current energy system have to change, such as e.g. modifications to the grid, demand side management, or investment into new technology.

The scope of this work is to investigate the stochastic effects in power system dynamics and control. For this purpose we aim to develop an integrated stochastic model, which reflects the grid codes for power frequency control by the *European Network of Transmission Operators* (ENTSO-E). The power frequency measurements reveal clear signatures of the grid codes. We present these results and outline the intended stochastic modelling approach.

SOE 22.9 Fri 12:15 ZEU 160

Principal Components of the European Power System — •Fabian Hofmann, Jonas Hoersch, and Stefan Schramm — Frankfurt Institute for Advanced Studies, Frankfurt, Germany

The European power system represents a huge network of different nodes, each with a complex time-dependent behaviour. In order to efficiently integrate renewable energy sources, such as wind and solar, it is a major task to understand and handle their additional effects. In particular, the more renewables in the system, the more the power generation will be subject to the weather. We therefore build up a european power system, which is dominated by non-conventional power generators, and extract general time-dependant patterns from it by applying a Principal Component Analysis to the timeseries of the nodes. This reduces the multivariate dimension of the system to a small number of general patterns, which are though uncorrelated but may not necessarily be statistically independent. Furthermore, these dominating patterns determine main flows in the network and can be used to align investments and network design.