DY 6: Delay Dynamics

Time: Monday 15:00–16:30 Location: MA 144

DY 6.1 Mon 15:00 MA 144

Cluster synchronization in neural networks with delayed coupling — •Johannes Pardowitz[1], Judith Lehnert[1], Thomas Dahms[1], Philipp Hövel[1,2], and Eckehard Schöll[1] — [1]Technische Universität Berlin, Germany — [2]Bernstein Center for Computational Neuroscience Berlin, Germany

We study zero-lag and cluster synchronization on delay-coupled neural networks, considering simple network motifs and small-world networks of FitzHugh-Nagumo models. We systematically investigate the influence of the network topology and the initial conditions on the dynamical synchronization patterns. In addition, the desynchronization transition induced by additional inhibitory links [1] is discussed.

[1] J. Lehnert, T. Dahms, P. Hövel, and E. Schöll: *Loss of synchronization in complex neural networks with delay*, Europhys. Lett. (2011), in print (arXiv:1107.4195).

DY 6.2 Mon 15:15 MA 144

Dynamical properties of delay-coupled stochastic networks: On spectra, correlations and network topology — •Otti D'Huys[1,2], Raul Vicente[3], Jan Danckaert[2], and Ingo Fischer[4] — [1]Institut für Theoretische Physik, Universität Würzburg, Germany — [2]Applied Physics Research Group (APHY), Vrije Universiteit Brussel, Belgium — [3]Max-Planck-Institute for Brain Research, Frankfurt am Main, Germany — [4]Instituto de Fisica Interdisciplinar y Sistemas Complejos, IFISC (UIB-CSIC), Palma de Mallorca, Spain

The dynamical properties of delay-coupled systems are of high current interest. So far the analysis has concentrated strongly on synchronisation properties. Here, we study how the network structure affects the dynamical properties of the nodes, if they do not synchronise completely. Therefore we study networks of stochastic linear units with delayed coupling, which cannot adapt their output to each other to show identical synchronisation. For these systems we can calculate analytically the correlation functions of the dynamics of different network nodes, and the corresponding spectra.

We find that both the spectrum and the autocorrelation function of a network element can be expressed as the average of the spectra of different single nodes with delayed feedback. We compare the correlation and spectral properties of stochastic linear maps to those of deterministic chaotic dynamical system. Although linear maps cannot show any form of synchrony, simply due to the network structure, they show correlation patterns and spectra that are strikingly similar to those observed in some deterministic chaotic delay-coupled networks.

DY 6.3 Mon 15:30 MA 144

Synchronization in networks of noisy oscillators with delayed coupling — •Andrea Vüllings[1,2], Valentin Flunkert[1], and Eckehard Schöll[1] — [1]Technische Universität Berlin, Germany — [2]Humboldt Universität zu Berlin, Germany

We investigate networks composed of delay-coupled noisy dynamical components. We concentrate on directed and undirected ring networks (regular networks). The local dynamics of each network agent is given by a stable focus, and each node is subject to Gaussian white noise. We discuss the influence of the coupling delay time on the stochastic network dynamics. By decomposing the general solution for the network dynamics into network modes, we analyze the mean square oscillation amplitude of the nodes for variable delay times. We derive an analytic expression for the mean square amplitude and find that by choosing a suitable delay time the noise induced collective oscillations can be enhanced or suppressed. Numerically, we also discuss the case of a Hopf normal form as the local dynamics of the individual network components and compare these simulations to the analytical results obtained for the linear case.

DY 6.4 Mon 15:45 MA 144

Dynamics of semiconductor lasers with delayed polarization-rotated feedback and its application for fast random bit generation — •Neus Oliver[1], Miguel C. Soriano[1], David W. Sukow[2], and Ingo Fischer[1] — [1]Instituto de Física Interdisciplinar y Sistemas Complejos (IFISC) CSIC-UIB, Campus Universitat de les Illes Balears, E-07122 Palma de Mallorca, Spain — [2]Department of Physics and Engineering, Washington and Lee University, Lexington, Virginia 24450 USA.

Chaotic dynamics of semiconductor lasers has been proven attractive for fast random bit generation. Simple and robust systems, along with a systematic approach determining the required dynamical properties and most suitable conditions are key to achieve this goal. We show that the dynamics of a single mode laser with polarization-rotated feedback is very attractive for random bit generation. The delayed feedback induces dynamical instabilities characterized by a broad RF spectrum and corresponding chaotic dynamics of the output signal. We identify the optimal operating conditions and derive the sampling conditions to achieve randomness. Finally, we introduce a simple postprocessing procedure and study its role to enhance randomness. Applying the identified criteria, we achieve fast random bit generation rates up to multi-Gbit/s with a simple and robust system and minimal postprocessing requirements.

DY 6.5 Mon 16:00 MA 144

Strong and Weak Chaos in Nonlinear Networks with Time-Delayed Couplings — •Sven Heiligenthal[1], Thomas Dahms[2], Serhiy Yanchuk[3], Thomas Jüngling[1], Valentin Flunkert[2], Ido Kanter[4], Eckehard Schöll[2], and Wolfgang Kinzel[1] — [1]University of Würzburg, Würzburg, Germany — [2]Technical University of Berlin, Berlin, Germany — [3]Humboldt University of Berlin, Berlin, Germany — [4]Bar-Ilan University, Ramat-Gan, Israel

We investigate networks of nonlinear units with time-delayed couplings in the limit of large delay times. We find two kinds of chaos which we call strong and weak. For strong chaos the largest Lyapunov exponent (LE) is of the order of the inverse time scales of the individual units. For weak chaos the largest LE is of the order of the inverse delay time. As a consequence, networks with strong chaos cannot synchronize, whereas for weak chaos, networks can synchronize if the product of the largest LE and the delay time is sufficiently small compared to the eigenvalue gap of the coupling matrix. We can prove that the occurrence of strong and weak chaos is determined by the sign of the instantaneous LE. For semiconductor lasers, numerical simulations of the Lang-Kobayashi equations predict that by monotonically increasing the strength of the time-delayed coupling or feedback, the chaos changes from weak to strong and back to weak chaos. We suggest an experimental setup to measure the difference between strong and weak chaos, which we have realized in an experiment with two coupled electronic circuits.

See also: S. Heiligenthal *et al.*, Phys. Rev. Lett. **107**, 234102 (2011).

DY 6.6 Mon 16:15 MA 144

Experimental control of chaos by variable and distributed delay feedback — •Thomas Jüngling[1], Aleksandar Gjurchinovski[2], and Viktor Urumov[2] — [1]Institute for Theoretical Physics, University of Würzburg, Germany — [2]Faculty of Natural Sciences and Mathematics, Saints Cyril and Methodius University of Skopje, Macedonia

Unstable steady states can be stabilized by time-delayed feedback with variable or distributed delay. Compared to the classical control method with a single constant delay, it has been theoretically shown that such kind of feedback can improve the stability properties significantly. Here we investigate this phenomenon experimentally for a chaotic electronic circuit. Time-delayed signals are obtained by use of digital delay lines, which are driven by an external clock. A modulation of the clock frequency results in a delay time modulation. The use of many delay lines as well as the application of filters results in a delay distribution. The steady state of the oscillator could be stabilized with these methods for comparably large sets of parameters, confirming the theoretical prediction and the robustness of the presented technique. A restricted version of our control scheme was successfully applied to the control of unstable periodic orbits, also resulting in improved stabilization. Finally, an intuitive explanation of the phenomenon is given in terms of classical diffraction and interference.