# DY 43 Signals and neuronal Networks

Time: Thursday 11:30–12:45 Room: SCH 251

DY 43.1 Thu 11:30 SCH 251

**Precise Timing in Strongly Heterogeneous Neural Networks with Delay** — •Raoul-Martin Memmesheimer[1,2] and Marc Timme[1,2,3] — [1]Max-Planck-Institut für Dynamik und Selbstorganisation (MPIDS) Göttingen — [2]Bernstein Center for Computational Neuroscience BCCN Göttingen — [3]Center for Applied Mathematics, Cornell University, Ithaca, USA

Precise timing of spikes is discussed to be a key element of neural computation [1], but it is still an open question how patterns of precisely timed spikes emerge in the dynamics of neural networks [2]. Here we demonstrate that and how deterministic neural networks which simultaneously exhibit delayed interactions [3], complex topology [4] and strong heterogeneities can yet display periodic patterns of spikes that are precisely timed. We develop an analytical method to design networks that display a given non-degenerate pattern with realistic temporal extent and complicated temporal structure. We point out that the same pattern can exist in very different networks; its stability depends on the particular coupling architecture. Using a nonlinear stability analysis, we show that networks with purely inhibitory (or purely excitatory) coupling can either store only stable or only unstable patterns.

[1] M. Abeles, *Science* **304**:523 (2004).
[2] I.J. Matus Bloch, C. Romero Z., *Phys. Rev. E* **66**:036127 (2002); D.Z. Jin, *Phys. Rev. Lett.* **89**:208102 (2002); M. Denker et al., *Phys. Rev. Lett.* **92**:074103 (2004).
[3] U. Ernst, K. Pawelzik, T. Geisel, *Phys. Rev. Lett.* **74**:1570 (1995).
[4] M. Timme, F. Wolf, T. Geisel, *Phys. Rev. Lett.* **89**:258701 (2002).

DY 43.2 Thu 11:45 SCH 251

**Delay induced instability in a small neural network model** — •Bernhard Heislbetz[1] and Arne Wunderlin[2] — [1]DLR Lampoldshausen, Institut für Raumfahrtantriebe, D-74239 Hardthausen — [2]Universität Stuttgart, 1. Institut für Theoretische Physik , D-70550 Stuttgart

We present the linear stability analysis of a small neural network model consisting of two neurons with time-delayed coupling and feedback. Numerical simulations illustrate the analytical results and show the dynamical behavior of the neural network model after destabilisation.

DY 43.3 Thu 12:00 SCH 251

**Phase-Rectified Signal Averaging Detects Quasi-Periodicities in Non-Stationary Data** — •J. W. Kantelhardt[1], A. Bauer[2], A. Bunde[3], P. Barthel[2], R. Schneider[2], M. Malik[4], and G. Schmidt[2] — [1]Fachber. Physik u. Zentr. f. Computational Nanoscience, Martin-Luther-Universität, Halle (Saale), Germany — [2]Med. Klinik u. Dt. Herzzentrum der Technischen Universität München, Germany — [3]Inst. f. Theoretische Physik III, Justus-Liebig-Universität, Giessen, Germany — [4]Dept. of Cardiac and Vascular Sciences, St. George's, University of London, UK

We present an efficient technique for the study of quasi-periodic oscillations in noisy, non-stationary signals, which allows the assessment of system dynamics despite phase resetting and noise. It is based on the definition of anchor points in the signal (in the simplest case increases or decreases of the signal) which are used to align (i. e., phase-rectify) the oscillatory fluctuations followed by an averaging of the surroundings of the anchor-points. We give theoretical arguments for the advantage of the technique, termed phase-rectified signal averaging (PRSA), over conventional spectral analysis and show in a numerical test using surrogate heartbeat data that the threshold intensity for the detection of additional quasi-periodic components is approximately 75% lower with PRSA. With the use of different anchor point criteria PRSA is capable of separately analysing quasi-periodicities that occur during increasing or decreasing parts of the signal.

DY 43.4 Thu 12:15 SCH 251

**Influence of negative feedback on the dynamics of a stochastic signalling module** — •Peter Borowski, Manoj Gopalakrishnan, Frank Jülicher, and Martin Zapotocky — Max-Planck-Institut für Physik komplexer Systeme, Nöthnitzer Str. 38, 01187 Dresden

We study the stochastic kinetics of a two-state signalling module. In the active state, the module produces a chemical species which enhances the rate of deactivation, giving raise to negative feedback. Examples are an ion channel whose closing rate depends on the ion concentration that it conducts, or a gene whose protein product acts as a repressor. We develop a path-integral formulation of the two-state process, based on the temporal statistics of its state-flips. In the limit of weak feedback, analytic results are obtained for the mean values and correlationfunctions as well as response functions. Monte Carlo simulations are performed which support these analytical predictions and provide results beyond linear perturbation theory.

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**One dimensional driven lattice gas of dimers coupled to on-off bulk kinetics** — •Paolo Pierobon[1,2], Thomas Franosch[1,2], Mauro Mobilia[1], and Erwin Frey[1] — [1]Arnold Sommerfeld Center, Theresienstr.37, D-80333 Muenchen — [2]Hahn-Meitner Institut, Glienickerstr.100, D-14109 Berlin

We investigate the properties of a system that couples the Totally Asymmetric Simple Exclusion Process (TASEP) to the on/off kinetics in the bulk. We consider extended particles showing the robustness of the picture found in the case of monomers. We highlight analogies and differences between monomers and dimers using a refined mean field analysis (consistent with both the TASEP part and the on/off bulk kinetics) to rationalize the Monte Carlo data and derive the phase diagram. Furthermore we investigate the effect of the presence of a bottleneck in this kind of systems.