DY 31: Networks, From Topology to Dynamics – Part I (joint session SOE/DY)

Time: Wednesday 9:30–11:00 Location: GÖR/0226

Invited Talk DY 31.1 Wed 9:30 GÖR/0226

Dynamics and Structure in Temporal Networks — •Natasa Djurdjevac Conrad — Zuse Institute Berlin, Germany

Temporal networks are a powerful tool for describing real-world systems in which interactions change over time, such as social contacts or transportation systems. Understanding how these networks evolve is crucial for uncovering the mechanisms that drive system behavior. From a dynamical systems perspective, clustering temporal networks and tracking the dynamics of clusters enables the identification of long-lived structures, metastable states and tipping points. In this talk, I will present recent work on temporal network analysis using random walk-based approaches, with a focus on network clustering and detecting structurally coherent time-periods. These methods provide a natural connection between network science and dynamical systems, relating to transfer operator frameworks and spectral theory. Through examples from synthetic models and real-world datasets, I will illustrate how these tools uncover key patterns and dynamic changes in complex networks.

DY 31.2 Wed 10:00 GÖR/0226

From Quiescence to Synchrony: Noise-Shaped Dynamics in Coupled Neuronal Systems — •Max Contreras[1,2] and Philipp Hövel[2] — [1]Technische Universität Berlin, Germany — [2]Saarland University, Saarbrücken, Germany

Stochastic fluctuations are usually regarded as promoters of activity in excitable and oscillatory systems, giving rise to phenomena such as coherence resonance. Here, we show that the opposite can occur in the small-noise regime, where noise can inhibit spiking activity in weakly coupled neuronal units. Using a ring of diffusively coupled, oscillatory FitzHugh-Nagumo neurons, we demonstrate how the interplay of noise and coupling strength generates different collective behaviors. We systematically classify the dynamical scenarios by an in-depth time-series analysis that combines multiple, complementary measures. As a result, we are able to automatically identify distinct dynamical clusters in parameter space: quiescent state, noisy synchronization, complete synchronization, and intermittent switching. The presented workflow can be universally applied in coupled oscillator networks and provides a unified framework to study collective dynamics.

15 min. break

DY 31.3 Wed 10:30 GÖR/0226

Learning collective variables for time-evolving networks — •Sören Nagel, Nataša Djurdjevac Conrad, Stefanie Winkelmann, and Marvin Lücke — Zuse Institute Berlin

We address the challenge of model reduction for time-evolving networks by identifying collective variables for stochastic rewiring processes driven by opinion homophily. [Lücke et al., Phys. Rev. E 109, L022301 (2024); Djurdjevac Conrad et al., Chaos 34, 093116 (2024)].

Utilizing the *transition manifold framework*, we identify a simple consensus measure as a collective variable for an ergodic and a non-ergodic model, and learn the dynamics of the projected system. We show that the learned model reduction can be obtained from the corresponding graphon process in the case of large and not too sparse graphs with uniformly distributed opinions. Our data-driven approach successfully identifies the collective variables in more general cases, highlighting the possibility to study low-dimensional model reductions in systems that have not been understood theoretically.

DY 31.4 Wed 10:45 GÖR/0226

Time-delayed dynamics in regular networks of Kuramoto oscillators with inertia — •Philipp Hövel[1], Esmaeil Mahdavi[2], Mina Zarei[2], and Farhad Shahbazi[3] — [1]Saarland University, Saarbrücken, Germany — [2]Institute for Advanced Studies in Basic Sciences, Zanjan, Iran — [3]Isfahan University of Technology, Isfahan, Iran

We investigate the complex interplay between inertia and time delay in regular rotor networks within the framework of the second-order Kuramoto model. By combining analytical and numerical methods, we demonstrate that intrinsic time delays – arising from finite information transmission speeds – induce multistability among fully synchronized phase-locked states. Unlike systems without inertia, the presence of inertia destabilizes these phase-locked states, reduces their basin of attraction, and gives rise to nonlinear phase-locked dynamics over specific inertia ranges. In addition, we show that time delays promote the emergence of turbulent chimera states, while inertia enhances their spatial extent. Notably, the combined influence of inertia and time delay produces dynamic patterns reminiscent of partial epileptic seizures. These findings provide new insights into synchronization phenomena by revealing how inertia and time delay fundamentally reshape the stability and dynamics of regular rotor networks, with broader implications for neuronal modeling and other complex systems.