DY 73: Poster: Networks, Chimera, Energy Systems

Time: Thursday 15:30–18:00 Location: Poster A

DY 73.1 Thu 15:30 Poster A

Reconstructing food webs from time series — •Bernd Fernengel[1], Jose Casadiego[2], and Marc Timme[2] — [1]Instituts für Festkörperphysik, Technische Universität Darmstadt, Hochschulstraße 6, 64289 Darmstadt — [2]cfaed - Center for Advancing Electronics Dresden, Technische Universität Dresden, Zellescher Weg 17, 01069 Dresden

Feeding relations in food webs (networks of 'who eats whom' in an ecosystem) determine the time evolution of the biomass of each species. Yet, such links are difficult to be measured directly and are often inaccessible. State-of-art approaches rely on time series of biomasses to establish links between species via pairwise statistical dependencies, although these are prone to recover indirect interactions. Here, we extend the Algorithm for Revealing Network Interactions (ARNI) and demonstrate that sufficiently long time series of biomasses reveal the actual topology of food webs. Furthermore, we show that our approach also determines whether a species has a positive or a negative influence on other species, which is crucial given that a single species interacts with both its predators and preys. Finally, we compare the performance of our approach with other benchmarks and discuss scalability for increasing food web sizes.

DY 73.2 Thu 15:30 Poster A

Pattern formation in games of winnerless competition — •Maximilian Voit and Hildegard Meyer-Ortmanns — Jacobs University, Bremen, Germany

We study models of winnerless competition in the framework of evolutionary game theory [1]. We choose the predation rules and rates in a way that yields a network of heteroclinic orbits for the local dynamics at each site of a spatial grid. Moreover we analyze the impact on spatial pattern formation for games with individual sites coupled via diffusion. We then discuss how to choose the rules on the microscopic level in view of desired domains, coalitions, or alliances on a coarse scale.

[1] D. Labavic and H. Meyer-Ortmanns, Rock-paper-scissors played within competing domains in predator-prey games, J. Stat. Mech., 113402˜1-21 (2016).

DY 73.3 Thu 15:30 Poster A

Statistical mechanics and condensation into multiple states — •Sina Sadeghi and Andreas Engel — Institut für Physik, Carl von Ossietzky Universität Oldenburg, Germany

Condensation processes are ubiquitous in a diverse range of physical phenomena. They occur via collective behaviour of systems comprising many identical interacting entities that each of which may be in one of different possible states. Typically, states are filled by a small number of system components. Condensation occurs by definition if one or multiple states are macroscopically occupied such that a non-zero fraction of all components share the same state. In the present work we employ statistical mechanics methods from disordered systems to investigate static properties of condensation in a general framework. We consider the replicator equation with skew symmetric matrices that can describe the dynamics of condensation into multiple states. We show how typical properties of random interaction matrices play a vital role in manifesting the statistics of condensate states. In particular, an analytical expression for the fraction of condensate states in the thermodynamic limit is provided and the result is confirmed by numerical simulations.

DY 73.4 Thu 15:30 Poster A

Understanding pattern formation in climate networks based on aquaplanet simulations — •Frederik Wolf[1,2], Catrin Kirsch[1], and Reik Donner[1] — [1]PIK, Potsdam, Germany — [2]HU, Berlin, Germany

During the recent years, it has been shown that tools from complex network theory can effectively extract spatio-temporal variability patterns from climate data. While a close linkage between classical empirical orthogonal functions and network degree has been analytically demonstrated, the interpretation of other higher-order network measures like betweenness in such climate networks has remained an open problem so far.

Here, we aim to disentangle the information on the underlying climate dynamics provided by various network measures. For this purpose, we study datasets from so-called aquaplanet simulations performed within the TRACMIP coordinated experiment.

We construct network representations based upon the spatial correlation structures of temperature, wind, geopotential height and precipitation fields and perform a detailed study on the resulting patterns exhibited by different topological and spatial network characteristics. Some of the obtained network structures can be linked with mechanisms known from the Earth's climate system, while others are specific to the aquaplanet setup. By systematically investigating similarities and differences, we contribute to a better understanding of pattern formation in climate networks.

DY 73.5 Thu 15:30 Poster A

Maximum entropy method for analysis and design of photonic communication networks — •Tobias Kussel[1], Felix Wissel[2], and Barbara Drossel[1] — [1]Institute for Condensed Matter Physics, Technische Universität Darmstadt, D-64289 Darmstadt, Germany — [2]IP Carrier & Broadband Networks, Deutsche Telekom, Fixed Mobile Engineering Deutschland, D-64295 Darmstadt, Germany

We present a novel approach to analyzing and planning photonic communication networks using concepts from statistical physics and information theory.

Communication networks play a crucial role in modern life infrastructure. When planning and operating such a network, resilience in case of failures as well as costs of infrastructure have to be taken into account. Classical network design algorithms are based on integer linear programming and are located well within the non-polynomial complexity realm.

To achieve a nearly optimal combination of resilience and cost efficiency, we use the topological analysis of neighbourhood graphs and a maximum entropy routing and spectrum assignment strategy. Combining the topological characteristics with the dynamic load properties under maximum entropy distribution we achieve a highly fault resistant as well as cost optimized fiber network.

DY 73.6 Thu 15:30 Poster A

Inhibition as a determinant of activity and criticality in dynamical networks — •Joao Pinheiro Neto[1], Marcus Aloizio Martinez de Aguiar[2], José Antônio Brum[2], and Stefan Bornholdt[3] — [1]Max Planck Institute for Dynamics and Self-Organization, Goettingen, Germany — [2]State University of Campinas, Campinas, Brazil — [3]University of Bremen, Bremen, Germany

Inhibition appears to be a common trait of dynamical networks in nature, ranging from neural networks and biochemical networks, to social and technological networks. We here study the role of inhibition in a representative dynamical network model, characterizing the dynamics of random threshold networks (RTNs) with both excitatory and inhibitory links. We find the balance between excitatory and inhibitory links to be a key parameter in the dynamics. Varying the fraction of inhibitory links has a strong effect on the network's stable population activity A_∞ and sensitivity to perturbation λ. We develop mean-field approximations for A_∞ and λ, and find that the dynamics is independent of degree distribution in the high degree limit. Instead, the amount of inhibition is a determinant of dynamics and sensitivity, allowing for criticality ($\lambda = 1$) only in a specific corridor of inhibition. In a minimal model of an adaptive threshold network we demonstrate how the dynamics remains robust against changes in the topology. This adaptive model can be extended in order to generate networks with a controllable activity distribution and specific topologies.

DY 73.7 Thu 15:30 Poster A

Phase balancing in the Kuramoto model on small networks — •Franz Kaiser and Karen Alim — Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany

Weakly interacting oscillators play a crucial role for transport and timing along a broad range of systems, from biological systems to powergrids and control of autonomous vehicles. In many oscillator networks the interaction is constrained by boundary effects or conservation laws. Among theoretical models used for coupled oscillators on networks, the Kuramoto model stands out due to its tractability and applicability. While research regarding the Kuramoto model has mainly focused

on synchronization phenomena, so called phase balanced states are important for constrained systems. An example occurring in nature are the periodically contracting tubes of the network-shaped organism *Physarum polycephalum*. Here, conservation of fluid volume enclosed within the tubular network is prohibiting synchronized contractions. However, very little is known on the structure of balanced states and the networks stabilizing these in Kuramoto's model. Here, we investigate a certain class of networks in which balanced states turn out to be stable and compare them to networks formed by *P. polycephalum*. The structure of this class of networks is highly symmetric, while the underlying graphs are in general neither circulant nor regular. We derive analytical results correctly characterizing the scaling of phase balanced states with increasing number of nodes in a subclass of the networks found. Our findings point out that network architectures that differ from circulant graphs may well support stable phase balanced states.

DY 73.8 Thu 15:30 Poster A

Chimera states in complex networks: interplay of fractal topology and delay — •Jakub Sawicki, Iryna Omelchenko, Anna Zakharova, and Eckehard Schöll — Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin, Germany

Chimera states are an example of intriguing partial synchronization patterns emerging in networks of identical oscillators. They consist of spatially coexisting domains of coherent (synchronized) and incoherent (desynchronized) dynamics. We analyze chimera states in networks of FitzHugh-Nagumo oscillators with hierarchical connectivities, and elaborate the role of time delay introduced in the coupling term. In the parameter plane of coupling strength and delay time we find tongue-like regions of existence of chimera states alternating with regions of synchronization. We demonstrate that by varying the time delay one can deliberately stabilize desired spatio-temporal patterns in the system.

DY 73.9 Thu 15:30 Poster A

Avoiding coion trapping in nanoporous supercapacitors — Konrad Breitsprecher[1], •Svyatoslav Kondrat[2] und Christian Holm[1] — [1]Institute for Computational Physics, Stuttgart — [2]Institute of Physical Chemistry, Warsaw

Nanoporous supercapacitor have attracted much attention recently as energy storage devices with remarkable cyclability, and high power and energy densities. However, their use in high frequency applications might be limited by a relatively slow charging process. In this molecular dynamics simulation study of a slit-pore capacitor system, [1] we focus on the physics and optimization of charge/discharge cycles. We will see that step-voltage charging is slow because the coions become trapped in narrow pores of supecapacitor electrodes. To avoid such trapping, a slow voltage-sweep charging is considered, which allows to accelerate the overall charging process substantially. However, we will demonstrate that a step-voltage, rather than sweeping, is preferable for fast discharging. Based on these results we will propose an optimal charge/discharge cycle.

[1] The effect of finite pore length on ion structure and charging (https://doi.org/10.1063/1.4986346)

DY 73.10 Thu 15:30 Poster A

Thermodynamic modelling of a Vuilleumier refrigerator — Abdellah Khodja, •Raphael Paul, and Karl Heinz Hoffmann — Technische Universität Chemnitz, Institut für Physik, 09107 Chemnitz, Germany

The Vuilleumier machine is a thermodynamic device which can act as both, heat pump and refrigerator. The working principle is based on the gas displacement between three different temperature niveaus by two gas displacers. Thus, no further working pistons are required. We develop a thermodynamic model of the Vuilleumier refrigerator in the context of endoreversible thermodynamics. The model is based on empirical transport laws which enable a simplified description of the complex transport phenomena and flow properties. The influence of several parameters on the cooling performance is studied.

DY 73.11 Thu 15:30 Poster A

Analyzing a Novel Method of Power Control for Internal Combustion Engines — •Andreas Fischer and Karl Heinz Hoffmann — Institut für Physik – Technische Universität Chemnitz – 09107 Chemnitz – Germany

Vehicles are mainly powered by combustion engines. Thus, improving these engines efficiency reduces both their operational cost as well as the emission of greenhouse gases and other pollutants. Within this work a novel approach to control the engine power is analyzed, utilizing a feature rich 1-D engine simulation. It is found that this method promises an efficiency gain of up to 2 percentage points compared to the common power control method while running the otherwise identical engine to drive a medium load (relative to its capability).