DY 51: Networks: From Topology to Dynamics (joint session DY/SOE)

Time: Wednesday 15:30–18:00 Location: MA 001

DY 51.1 Wed 15:30 MA 001

Mapping and discrimination of networks in the complexity-entropy plane — •Marc Wiedermann[1,2], Jonathan F. Donges[1,3], Jürgen Kurths[1,2], and Reik V. Donner[1] — [1]Potsdam Institute for Climate Impact Research — [2]Humboldt University of Berlin — [3]Stockholm Resilience Centre

Complex networks are usually characterized in terms of their topological, spatial, or information-theoretic properties and combinations of the associated metrics are used to discriminate networks into different classes or categories. However, even with the present variety of characteristics at hand it remains a subject of current research to appropriately quantify a network's complexity and correspondingly discriminate between different types of complex networks on such a basis. Here we explore the possibility to classify complex networks by means of a statistical complexity measure that has formerly been successfully applied to distinguish different types of chaotic and stochastic time series. It is composed of a network's averaged per-node entropic measure characterizing the network's information content and the associated Jenson-Shannon divergence as a measure of disequilibrium. We study 29 real-world networks and show that networks of the same category cluster in distinct areas of the resulting complexity-entropy plane. In particular, connectome networks exhibit among the highest complexity while transportation and infrastructure networks display significantly lower values. We further show that the proposed framework is useful to objectively construct threshold-based networks by choosing the threshold such that the statistical complexity is maximized.

DY 51.2 Wed 15:45 MA 001

Renormalisation group theory for percolation in time-varying networks — •Jens Karschau, Marco Zimmerling, and Benjamin M. Friedrich — cfaed | TU Dresden, Dresden, Germany

Wireless communication networks require reliable routing of messages, despite the fact that individual networks links are unreliable. Multi-hop routing protocols propose a promising solution to overcome the issue of message loss. For these protocols, successful relay of a message defines a percolation problem.

Here, we present a percolation theory for a minimal model, where individual links switch between an active and an inactive state according to a two-state Markov process. Using renormalization group theory, we analytically compute the complete statistics of failure events. We show how the time-dependent probability to find a path of active links between two designated nodes converges towards an effective Bernoulli process, i.e. without memory, as the hop distance between the nodes increases. Our work extends classical percolation theory to the dynamic case. It elucidates temporal correlations of message losses with implications for the design of communication protocols and control algorithms.

Reference: arXiv:1708.05704

DY 51.3 Wed 16:00 MA 001

Self-organized cluster formation in neural networks — •Rico Berner[1,2], Eckehard Schöll[1], and Serhiy Yanchuk[2] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Germany — [2]Institut für Mathematik, Technische Universität Berlin, Germany

We investigate collective behaviour in a network of adaptively coupled phase oscillators, where the coupling topology depends on the dynamics of oscillators. We show that such a system gives rise to numerous dynamics, including hierarchical multi-clusters and chimera states. Our numerical and analytical results are compared and interpreted with respect to pattern formation due to learning processes and the multi-layer structure of the human brain.

DY 51.4 Wed 16:15 MA 001

Coarsening dynamics of ferromagnetic granular networks - experiment and simulation — •Pedro A. Sanchez[1], Armin Kögel[2], Robin Maretzki[2], Tom Dumont[2], Elena S. Pyanzina[3], Sofia S. Kantorovich[1], and Reinhard Richter[2] — [1]Univ. of Vienna, Sensengasse 8, Vienna, 1090, Austria — [2]Experimentalphysik 5, Univ. of Bayreuth, 95440 Bayreuth, Germany — [3]Federal Univ., Lenin av. 51, Ekaterinburg, 620000, Russia

We investigate the phase separation of a shaken mixture of glass and magnetised steel spheres after a sudden quench of the shaker amplitude. Then transient networks of steel spheres emerge in the experiment. For the developing network we observe an initial regime, where the network incubates, followed by a regime where network structures are elongated and broken, and finally a regime where the structures have relaxed to compact clusters of rounded shapes. This phaenomenology resembles the initial, elastic and hydrodynamic regimes observed by H. Tanaka [J. Phys.: Cond. Mat., 2000] during the viscoelastic phase separation for dynamically asymmetric mixtures of polymers. In order to unveil the three regimes we measure order parameters like the mean number of neighbors and the efficiency.

To eluzidate the origin for a viscoelastic phase separation, we use a simple simulation approach to define the key interactions in the experimental system. This way, we discover that along with dipolar and steric interactions, a central attraction between the magnetised spheres is decisive for the coarsening dynamics. Our simulations show three regimes in the evolution of characteristic order parameters.

DY 51.5 Wed 16:30 MA 001

Coherence resonance in a network of FitzHugh-Nagumo systems: interplay of noise, time-delay and topology — •Maria Masoliver[1], Nishant Malik[2], Eckehard Schöll[3], and Anna Zakharova[3] — [1]Department of Physics, DONLL, Universitat Politècnica de Catalunya — [2]Department of Mathematics, Dartmouth College, Hanover, USA — [3]Institut für Theoretische Physik, Technische Universität, Berlin

The FitzHugh-Nagumo system is a paradigmatic model which describes the excitability and spiking behavior of neurons. This model, in the excitable regime under the influence of noise exhibits the counterintuitive phenomenon of coherence resonance: there exists an optimum intermediate value of the noise intensity for which noise-induced oscillations become most regular. We systematically investigate the phenomena of coherence resonance in time-delay coupled networks of FitzHugh-Nagumo elements in the excitable regime [1]. Using numerical simulations, we examine the interplay of noise, time-delayed coupling and network topology in the generation of coherence resonance. We demonstrate the possibility of controlling coherence resonance by varying the time-delay and the number of nearest neighbors. For a locally coupled ring, we show that the time-delay weakens coherence resonance. For nonlocal coupling with appropriate time-delays, both enhancement and weakening of coherence resonance are possible.

[1] M. Masoliver, N. Malik, E. Schöll, A. Zakharova, Chaos 27, 101102 (2017)

15 min. break

DY 51.6 Wed 17:00 MA 001

A Network Approach to Spin Systems Beyond Nearest-Neighbor Interactions — •Kathinka Gerlinger[1], Julian Heiss[1], Matthias Weidemüller[1,2], Andreas Spitz[3], and Michael Gertz[3] — [1]Physics Institute, Heidelberg University, Heidelberg, Germany — [2]Shanghai Branch, University of Science and Technology of China, Shanghai 201315, China — [3]Institute of Computer Science, Heidelberg University, Heidelberg, Germany

Investigating spin systems as examples of strongly-interacting systems and determining their phase diagram is a central research challenge in complex many-body physics. For the 1D Ising model with only nearest-neighbor interactions, Valdez et al. (arXiv:1508.07041) have recently shown the veracity and efficiency of complex network models with regard to finite-size scaling. We expand the task of finding the quantum phase transition of such spin systems beyond nearest neighbor interactions. To this end, we discuss suitable mappings of spin systems to complex networks and their analysis based on complex network analytic methods. Furthermore we investigate the evolution of spin states on dynamic networks and their relation to physical systems.

DY 51.7 Wed 17:15 MA 001

Self-consistent correlations of randomly coupled rotators in the asynchronous state — •Alexander van Meegen[1,2,3] and Benjamin Lindner[1,2] — [1]Humboldt Universität zu Berlin — [2]Bernstein Zentrum Berlin — [3]Forschungszentrum Jülich

We present a study of a network of unidirectionally coupled rotators with i.i.d. frequencies and i.i.d. coupling coefficients. Similar to bi-

ological networks, this system can attain an asynchronous state with pronounced temporal autocorrelations of the rotators.

Using an approach based on the system's generating functional, we derived a differential equation for the self-consistent autocorrelation function of the network noise. Its numerical solution has been confirmed by simulations of networks with Gaussian or sparsely distributed coupling coefficients. Explicit expressions for correlation function, power spectra, correlation time, noise intensity, and quality factor for the case of identical frequencies for all rotators in the limits of weak or strong coupling strength have been obtained.

This work paves the way for more detailed studies of how the statistics of connection strength, the heterogeneity of network parameters, and the form of the interaction function shape the network noise and the autocorrelations of the single element if this element has an predominantly oscillatory nature (e.g. a limit-cycle system).

DY 51.8 Wed 17:30 MA 001

Long-lasting desynchronization by coordinated reset stimulation in neuronal networks with spike-timing dependent plasticity — •Justus A. Kromer and Peter A. Tass — Stanford University, Stanford CA, USA

Abnormally strong synchronization of neuronal activity plays an important role in several brain disorders such as Parkinson's disease, epilepsy, and tinnitus. Deep brain stimulation is a therapy that specifically counteracts neuronal synchronization in related brain areas. In contrast to standard high-frequency deep brain stimulation, which aims on the suppression of neuronal activity, coordinated reset deep brain (CR) stimulation is intended to cause overall desynchronization by introducing phase shifts between individual neuronal subpopulations. To this end phase-resetting stimuli are applied to different neuronal subpopulations at different times. This results in a reshaping of the synaptic weights and, for well-chosen stimulation patterns, causes a transition from a pathological state with high synaptic weights and strongly-synchronized neuronal activity to a physiological state with low synaptic weights and desynchronized activity.

Using computer simulations, we study desynchronization by CR stimulation in networks of leaky integrate-and-fire neurons with spike-timing dependent plasticity. We present a novel approach for CR stimulation that significantly increases the field of application. Furthermore, we discuss the robustness of long-lasting desynchronization effects with respect to changes in system parameters such as network connectivity and heterogeneity in neuronal firing rates.

DY 51.9 Wed 17:45 MA 001

Wie klimawirksam ist der Photovoltaik-Zubau in Deutschland ? Verschwiegene Dynamik. — •Nikolaus von der Heydt — Umweltphysik Göttingen - Physik zum Leben - , Landolfshausen

Neue Analysen der weltweit vernetzten Prozessketten zur Herstellung von Si-PV-Anlagen (IEA 2011 bis 2016) ergeben, dass dabei global je kWp etwa 2,6 t CO2eq in die Atmosphäre gelangen, bevor die Anlagen in Deutschland in Betrieb gehen. Danach können sie hier pro Jahr durchschnittlich 475 Kg/kWp vermeiden, indem sie den aktuellen deutschen Strommix ersetzen. Damit dauert es 5,5 Jahre, bis ein jedes Jahr gleicher PV-Zubau eine Kapazität aufgebaut hat, die pro Jahr hier eben soviel CO2 vermeidet wie der Zubau global verursacht. Bis dahin wächst die CO2-Menge in der Atmosphäre an, bei z.B. 6 GWp/a auf 43 Mt. Danach überwiegt die Vermeidung, und nach 11 Jahren ist die CO2-Schuld getilgt. - Wirksamer Klimaschutz erfordert es, die CO2-Last des deutschen Strommix in 10 Jahren auf ca. 100 g/kWh zu senken, z.B. durch Ersatz von Braunkohle durch Windkraft mit Gas-KWK. Dann könnten deutsche PV-Anlagen je kWp nur noch 84 Kg/a vermeiden, und eine konstant wachsende PV-Kapazität könnte erst nach 30 Jahren die jährliche globale Herstellungs-Emission gerade kompensieren. Soll danach die erreichte Kapazität erhalten werden, müsste die bis dahin in der Atmosphäre angesammelte CO2-Menge für immer dort bleiben. Bei z.B. 6 GWp/a wären das 233 Mt. Mit Akkus und Freiland-Aufständerungen verdoppelt sich die Herstellungs-Emission mindestens, das bedeutet die 4-fache angesammelte CO2-Menge. Im Beispiel sind das 932 Mt - die deutsche Jahresemission.