Physics of Socio-economic Systems Division
Fachverband Physik sozio-ökonomischer Systeme (SOE)

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Overview of Invited Talks and Sessions

(Lecture halls H3 and H17; Poster A)

Plenary Talk by Cristopher Moore

PLV XIII	Thu	14:00–14:45	H2	**The Physics of Inference and Community Detection** — •Cristopher Moore

Young Scientist Award for Socio- and Econophysics (YSA) - Award Session and Prize Talk

SOE 11.1	Tue	14:00–14:45	H17	**From individual models of attitude change to patterns and dynamics of opinion landscapes** — •Jan Lorenz
SOE 11.2	Tue	15:00–15:45	H17	**The Dynamics of Social Conventions: From Names to Cryptocurrencies** — •Andrea Baronchelli

Invited Tutorial talks

SOE 1.1	Sun	16:00–16:50	H3	**Statistical network inference and community detection** — •Tiago Peixoto
SOE 1.2	Sun	16:50–17:40	H3	**Network filtering for big data** — •Tiziana Di Matteo
SOE 1.3	Sun	17:40–18:30	H3	**Multiscale simulations of soft matter augmented by data-driven methods** — •Tristan Bereau

Invited and Topical Talks

SOE 13.1	Wed	9:30–10:00	H17	**Inhibition induced explosive synchronization in multiplex network** — •Sarika Jalan
SOE 13.2	Wed	10:00–10:30	H17	**Percolation on multi-layer networks** — •Filippo Radicchi
SOE 13.3	Wed	10:45–11:15	H17	**Mean field phase synchronization across multilayer networks in chimera states** — •Ralph Gregor Andrzejak, Giulia Ruzzene, Kaspar Schindler, Eckehard Schöll, Anna Zakharova
SOE 15.1	Wed	15:00–15:30	H17	**Delay controls chimera relay synchronization in multiplex networks** — •Eckehard Schöll, Jakub Sawicki, Iryna Omelchenko, Anna Zakharova
SOE 19.1	Thu	15:00–15:45	H17	**Ecosystem stability and altruistic advantage** — •Nick Jones
SOE 19.4	Thu	16:15–16:45	H17	**Topological Hindrance and Jamming Transitions in Multi-Species Transport** — •Erwin Frey
SOE 19.5	Thu	17:00–17:45	H17	**Seeing and believing at super-resolution** — •Susan Cox
SOE 19.7	Thu	18:00–18:30	H17	**Reconstructing the topographic landscape of epithelial-mesenchymal plasticity** — •Francesc Font-Clos, Stefano Zapperi, Caterina A. M. La Porta

Invited talks of the joint Symposium SKM Dissertation-Prize 2019

See SYSD for the full program of the symposium.

SYSD 1.1	Mon	9:30– 9:50	H2	**Synchronization and Waves in Confined Complex Active Media** — •Jan Frederik Totz
SYSD 1.2	Mon	9:50–10:10	H2	**Spin scattering of topologically protected electrons at defects** — •Philipp Rüssmann
SYSD 1.3	Mon	10:10–10:30	H2	**Beyond the molecular movie: Revealing the microscopic processes behind photo-induced phase transitions** — •Chris W. Nicholson
SYSD 1.4	Mon	10:30–10:50	H2	**Thermodynamic bounds on current fluctuations** — •Patrick Pietzonka
SYSD 1.5	Mon	10:50–11:10	H2	**Lightwave-driven quasiparticle acceleration** — •Fabian Langer
SYSD 1.6	Mon	11:10–11:30	H2	**Ultrafast plasmon-driven point-projection electron microscopy** — •Jan Vogelsang
SYSD 1.7	Mon	11:30–11:50	H2	**Helimagnets, sand patterns and fingerprints linked by topology** — •Peggy Schönherr

Invited talks of the joint Symposium Patterns in Nature: Origins, Universality, Functions

See SYPN for the full program of the symposium.

SYPN 1.1	Mon	15:00–15:30	H1	**Engineering spatial-temporal organization of bacterial suspensions** — •Igor Aronson
SYPN 1.2	Mon	15:30–16:00	H1	**Collective behaviour and pattern formation in phoretic active matter** — •Ramin Golestanian
SYPN 1.3	Mon	16:00–16:30	H1	**Control and selection of spatio-temporal patterns in complex systems** — •Svetlana Gurevich
SYPN 1.4	Mon	16:45–17:15	H1	**Self-organization of Active Surfaces** — •Frank Jülicher
SYPN 1.5	Mon	17:15–17:45	H1	**Front instabilities can reverse desertification** — •Ehud Meron

Invited talks of the joint Symposium Czech Republic as Guest of Honor

See SYCZ for the full program of the symposium.

SYCZ 1.1	Thu	9:30–10:00	H4	**Crystal symmetries and transport phenomena in antiferromagnets** — •Tomas Jungwirth
SYCZ 1.2	Thu	10:00–10:30	H4	**Terahertz subcycle charge and spin control** — •Rupert Huber
SYCZ 1.3	Thu	10:30–11:00	H4	**1D molecular system on surfaces** — •Pavel Jelinek
SYCZ 1.4	Thu	11:15–11:45	H4	**Tunneling microscopy on insulators provides access to out-of-equilibrium charge states** — •Jascha Repp
SYCZ 1.5	Thu	11:45–12:15	H4	**Occam's razor and complex networks from brain to climate** — •Jaroslav Hlinka
SYCZ 1.6	Thu	12:15–12:45	H4	**Long range temporal correlations in complex systems** — •Holger Kantz

Sessions

SOE 1.1–1.3	Sun	16:00–18:30	H3	**Tutorial: Statistical Physics Methods for Data Science in Physics (joint SOE/DY/CPP/BP/jDPG) (joint session SOE/DY/TUT)**
SOE 2.1–2.4	Mon	9:30–11:00	H17	**Computational Social Science and Data Science I**
SOE 3.1–3.2	Mon	11:00–12:00	H17	**Financial Markets and Risk Management I**
SOE 4.1–4.3	Mon	12:00–12:45	H17	**Computational Social Science and Data Science II**
SOE 5.1–5.2	Mon	15:00–16:00	H17	**Financial Markets and Risk Management II**
SOE 6.1–6.10	Mon	15:00–17:45	H20	**Networks: From Topology to Dynamics (joint session DY/SOE)**
SOE 7.1–7.5	Mon	16:00–17:15	H17	**Social Systems, Opinion and Group Formation I**
SOE 8.1–8.4	Mon	17:15–18:30	H17	**Social Systems, Opinion and Group Formation II**
SOE 9.1–9.4	Tue	9:30–11:30	H17	**Economic Models**
SOE 10.1–10.2	Tue	11:30–12:30	H17	**Evolutionary Game Theory (joint SOE/BP/DY) (joint session SOE/BP)**

SOE 11.1–11.2	Tue	14:00–16:00	H17	**Award Session: Young Scientist Award for Socio-and Econophysics (YSA)**
SOE 12.1–12.17	Tue	16:00–19:00	Poster A	**Poster**
SOE 13.1–13.5	Wed	9:30–12:00	H17	**Dynamics of Multilayer Networks I (Focus Session SOE/DY/BP) (joint session SOE/DY/BP)**
SOE 14	Wed	12:00–13:00	H17	**Annual Member's Assembly**
SOE 15.1–15.5	Wed	15:00–16:45	H17	**Dynamics of Multilayer Networks II (Focus Session SOE/DY/BP) (joint session SOE/DY/BP)**
SOE 16.1–16.5	Thu	9:30–11:30	H17	**Networks and Systemic Risks (joint SOE/DY)**
SOE 17.1–17.3	Thu	10:30–11:15	H6	**The Physics of Power grids (joint session DY/SOE)**
SOE 18.1–18.4	Thu	11:30–12:30	H17	**Energy Networks (joint SOE/DY) (joint session SOE/DY)**
SOE 19.1–19.8	Thu	15:00–18:45	H17	**Focus Session: Theory of Stochastic Processes with Applications in Biology (joint session SOE/BP/DY/AKjDPG)**

Annual General Meeting of the Physics of Socio-economic Systems Division

Wed 12:00–13:00 H17

- Report on activities and general announcements.
- Miscellaneous and Disusssion.
- Elections.

SOE 1: Tutorial: Statistical Physics Methods for Data Science in Physics (joint SOE/DY/CPP/BP/jDPG) (joint session SOE/DY/TUT)

Big Data is an ubiquitious buzzword, but beyond storing and processing large datasets, challenges in applications often lie in high-dimensional and nontrivial structures (= the content!) within the datasets. Artificial intelligence approaches, paired with statistical physics methods, can provide powerful tools which can go far beyond standard statistical methods. The tutorial gives an overview both on methods from stochastic blockmodeling, network analysis, inference and machine learning and on applications ranging from socioeconomic networks to biomolecular simulations. (Session organized by Jens Christian Claussen and Andreas Fery with the divisions of SOE, DY, BP and CPP.)

Time: Sunday 16:00–18:30 Location: H3

Tutorial SOE 1.1 Sun 16:00 H3

Statistical network inference and community detection — •Tiago Peixoto — University of Bath, UK

Network structures are shaped by evolutionary mechanisms and determine the central aspects of how a system functions. However, differently from systems that are naturally embedded in space, we cannot simply "look" at network in order to extract its most important structural patterns. Instead, we must rely on well-founded algorithmic methods to extract this information from data in an interpretable way. In this tutorial, we review a principled approach to this problem based on the elaboration of probabilistic models of network structure, and their statistical inference from empirical data. We focus in particular on the detection of modules (or "communities") in networks.

We aim to cover the following topics: 1. The stochastic block model (SBM) and its variants (degree correction, overlapping groups, etc.); 2. Bayesian inference and model selection: Distinguishing structure from noise; 3. Generalizing from data: Prediction of missing and spurious links; 4. Model extensions: Layered, dynamic SBMs, and generalized models on continuous latent spaces; 5 Fundamental limits of inference, and the undetectability phase transition; 6. Efficient inference algorithms; 7. Network reconstruction from noisy or indirect data.

Tutorial SOE 1.2 Sun 16:50 H3

Network filtering for big data — •Tiziana Di Matteo — Department of Mathematics - King's College London

In this lecture I will present network-theoretic tools to filter information in large-scale datasets and I will show that these are powerful tools to study complex datasets. In particular I will introduce correlation-based information filtering networks and the planar filtered graphs (PMFG) and I will show that applications to financial data-sets can meaningfully identify industrial activities and structural market changes. It has been shown that by making use of the 3-clique structure of the PMFG a clustering can be extracted allowing dimensionality reduction that keeps both local information and global hierarchy in a deterministic manner without the use of any prior information. To advance the PMFG (currently O(N3)), I will introduce a new algorithm, the TMFG (Triangulated Maximally Filtered Graph), that efficiently extracts a planar subgraph which optimizes an objective function. The method is scalable to very large datasets and it can take advantage of parallel and GPUs computing. The method is adaptable allowing online updating and learning with continuous insertion and deletion of new data as well changes in the strength of the similarity measure. Finally I will also show that filtered graphs are valuable tools for risk management and portfolio optimization too and they allow to construct probabilistic sparse modeling for financial systems that can be used for forecasting, stress testing and risk allocation.

Tutorial SOE 1.3 Sun 17:40 H3

Multiscale simulations of soft matter augmented by data-driven methods — •Tristan Bereau — Max Planck Institute for Polymer Research

Multiscale simulations, all the way from quantum chemistry to continuum mechanics, probe a variety of length and time scales relevant to soft-matter systems. In this tutorial, I will describe different strategies to help improve physics-based simulations with recently-developed data-driven methods and concepts. Applications discussed will include Bayesian inference for molecular kinetics, machine learning to vastly improve force-field transferability, and high-throughput screening to explore chemical compound space.

SOE 2: Computational Social Science and Data Science I

Time: Monday 9:30–11:00 Location: H17

SOE 2.1 Mon 9:30 H17

Machine intelligence for network science and evolutionary dynamics? — •Jan Nagler[1] and Marc Timme[2] — [1]Frankfurt School — [2]TU Dresden

Does machine learning truly matter in network science or other sectors of statistical physics? Many network scientists, in particular those with a strong background in statistical physics, remain sceptical. This may be because computer science, traditionally, is more focussed on performance than on getting insights, offering transparency, being general or finding a minimal model. In [Timme & Nagler, News and Views: Pattern of Propagation, Nature Physics, in print] we argue that if fundamental principles underlying network dynamics are identified prior to the employment of intransparent black box feature extraction, not only hard tasks can be solved but also valuable insights may be provided. But this requires to frame our mathematical predictions according to the conditions under which the natural and artificial networks around us reveal themselves. Thus, this requires to bridge different disciplines through collaborations with researchers of complementary expertise. This talk aims to spread this message. We will exemplify this for seemingly universally optimal strategies (Generous Zero Determinant Strategies) and seemingly unresolvable (Prisoner's dilemma) conflicts of networked actors in complex noisy environments.

SOE 2.2 Mon 10:00 H17

Modeling the rise and fall of online topics — •Frederik Wolf[1,2], Philipp Lorenz-Spreen[3], Natasa Conrad[4], and Philipp Hövel[3,5] — [1]Potsdam Institute for Climate Impact Research, Research Domain 4 — [2]HU Berlin, Department of Physics — [3]TU Berlin, Department of Physics — [4]Zuse Institute, Berlin — [5]University College Cork, School of Mathematical Sciences

Hashtags are widely used for communication in online media. As a condensed version of information, they characterize topics and discussions. In this study, we split a weighted temporal network constructed from hashtag co-occurrences into static snaphots and utilize a higher order memory approach to produce a matching protocol that is robust toward temporal fluctuations and instabilities of the static community detection of each snapshot [Lorenz, Philipp, et al. "Capturing the Dynamics of Hashtag-Communities." Int. Wo. Compl. Netw. Appl., 2017].

The observations are characterized by bursty behaviors in the increases and decreases of hashtag usage. We consider the size of the communities in time as a proxy for online popularity and find that the gains and losses, as well as the interevent times are broadly distributed indicating occasional, but large and sudden changes in the usage of hashtags. Inspired by typical website designs, we propose a stochastic model that incorporates a ranking with respect to a time-dependent prestige score. The interplay of these mechanisms causes occasional cascades of rank shift events and reproduces the observa-

tions with good agreement. This offers an explanation for the observed dynamics, based on characteristic elements of online media.

SOE 2.3 Mon 10:15 H17

Activity-driven radicalization phenomena in public discussions — •Fabian Baumann[1], Philipp Lorenz-Spreen[2], Philipp Hövel[2], and Igor M. Sokolov[1] — [1]Institut für Physik - Humboldt-Universität zu Berlin — [2]Institut für Theoretische Physik - TU Berlin

We aim for a novel model for the description of the adoption of extreme opinions in a population of socially interacting agents, which we term radicalization. Inspired by multiple reports of strong opinion polarization, measurable from social media data and our own empirical insights into pre-election debates on Twitter, we investigate on the possible mechanisms of opinion reinforcement by peers. In a minimal scenario of binary opinion formation within a population, we introduce a simple mechanism of increasing conviction upon contacts to like-minded peers.

Combined with established concepts from constructive opinion dynamics models, this leads to two qualitatively different outcomes: (1) a global consensus and (2) a separation into two polarized (political) camps. On modern communication platforms, like Twitter, spreading information among a large number of peers became possible at low cost. Furthermore it is now, on a large-scale, possible to measure the occurring interactions. Extending our model by a simple mechanism for the activation of agents we aim for an explanatory link between the observed political opinion landscape and the (heterogeneously distributed) activities of social media users.

SOE 2.4 Mon 10:30 H17

A microscopic model of spatio-temporal language dynamics — •Michael Leitner[1], Katharina Prochazka[2,3], and Gero Vogl[2] — [1]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, 85748 Garching, Germany — [2]Fakultät für Physik, Universität Wien, 1090 Wien, Austria — [3]Institut für Slawistik, Universität Wien, 1090 Wien, Austria

With today's modes of long-distance communication, the local spatial scale is only of secondary importance for present cases of language shift. In contrast, in former times language dynamics was driven by the relocations and physical contacts between people on small scales. An ideal study object is afforded by the multinational Austro-Hungarian Empire, displaying both naturally evolving boundaries between language-defined populations, as well as small-scale heterogeneity due to colonist settlements [1].

For describing language dynamics at the scale of individual settlements, conventional reaction-diffusion approaches [2] are not applicable. Here we present a microscopic stochastic model, where individual births, deaths, relocations and language conversions are explicitly modelled. We parametrize our model with the historical census data available in ten-year intervals and give an interpretation of our findings in terms of the spatial interaction scale as well as a bias towards conversion to the language of the dominant group.

[1] K. Prochazka and G. Vogl, *PNAS* **114**, 4365 (2017)

[2] A. Kandler, R. Unger, and J. Steele, *Phil. Trans. R. Soc.* B **365**, 3855 (2010)

15 min. break

SOE 3: Financial Markets and Risk Management I

Time: Monday 11:00–12:00 Location: H17

SOE 3.1 Mon 11:00 H17

Multiscaling in Finance — •Tiziana Di Matteo — Department of Mathematics - King's College London

The multiscaling behaviour of financial time-series is one of the acknowledged stylized facts in the literature [1]. The source of the measured multifractality in financial markets has been long debated and it has been attributed to mainly two sources: the power law tails and the non linear autocorrelation of the analysed time-series [2,3]. In this talk I will discuss the origin of multiscaling in financial time-series and investigate how to best quantify it [4,5]. In particular I will show results on the application of the Generalized Hurst exponent tool to different financial time series and I will show the powerfulness of such tool to detect changes in markets' behaviours, to differentiate markets accordingly to their degree of development, to asses risk and to provide a new tool for forecasting.

[1] T. Di Matteo, Quantitative Finance 7(1) (2007) 21. [2] J. W Kantelhardt, Stephan A Zschiegner, Eva Koscielny-Bunde, Shlomo Havlin, Armin Bunde, and H Eugene Stanley, Physica A 316 (2002) 87-114. [3] Jozef Barunik, Tomaso Aste, T. Di Matteo, Ruipeng Liu, Physica A 391 (2012) 4234-4251. [4] R. J. Buonocore, T. Aste, T. Di Matteo, Chaos, Solitons and Fractals 88 (2016) 38-47. [5] R. J. Buonocore, T. Di Matteo, T. Aste, (2017), Phys.Rev.E 95 (4) (2017) 042311.

SOE 3.2 Mon 11:30 H17

Impact and recovery of mini flash crashes — Tobias Braun, Jonas A. Fiegen, Daniel C. Wagner, •Sebastian M. Krause, and Thomas Guhr — University of Duisburg Essen, Duisburg, Germany

Flash crashes with large price changes in short times imply large risks for investors. An example is the flash crash of May 6 in 2010 which produced one of the largest ever intraday point decline of the Dow Jones. There is also a large number of less drastic mini flash crashes, usually in only one stock at a time. The reasons of flash crashes are discussed controversially. Explanations span from large trades over market manipulation to feedbacks in trading algorithms. We have a closer look on the interplay between mini flash crashes and high frequency trading by using order flow data during the financial crisis [1]. We find that often single market orders dominate the flash crashes, which are therefore not triggered by algorithmic feedbacks. Furthermore we find that the price is often restored to levels close to the price before the flash crash.

[1] T. Braun, J.A. Fiegen, D.C. Wagner, S.M. Krause, T. Guhr, Impact and recovery process of mini flash crashes: An empirical study. PLoS ONE 13 (2018) e0196920.

SOE 4: Computational Social Science and Data Science II

Time: Monday 12:00–12:45 Location: H17

SOE 4.1 Mon 12:00 H17

Reconstructing networks with unknown and heterogeneous errors — •Tiago Peixoto — University of Bath, UK

The vast majority of network data sets contain errors and omissions, although this fact is rarely incorporated in traditional network analysis. Recently, an increasing effort has been made to fill this methodological gap by developing network-reconstruction approaches based on Bayesian inference. These approaches, however, rely on assumptions of uniform error rates and on direct estimations of the existence of each edge via repeated measurements, something that is currently unavailable for the majority of network data. Here, we develop a Bayesian reconstruction approach that lifts these limitations by allowing for not only heterogeneous errors, but also for single edge measurements without direct error estimates. Our approach works by coupling the inference approach with structured generative network models, which enable the correlations between edges to be used as reliable uncertainty estimates. Although our approach is general, we focus on the stochastic block model as the basic generative process, from which efficient nonparametric inference can be performed and yields a principled method to infer hierarchical community structure from noisy data. We demonstrate the efficacy of our approach with a variety of empirical and artificial networks.

SOE 4.2 Mon 12:15 H17

There is more in your Data! - Analysis of Complex, Interconnected Datasets using Semantic Data Modeling — Timm Fitschen[1,2], •Alexander Schlemmer[1,3], Henrik tom Wörden[1,2], Daniel Hornung[1], Ulrich Parlitz[1,2,3], and Stefan Luther[1,2,3,4,5] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Nonlinear Dynamics, Georg-August-Universität, Göttingen, Germany — [3]German Center for Cardiovascular Research (DZHK), partner site Göttingen, Germany — [4]Institute of Pharmacology and Toxicology, University Medical Center Göttingen, Göttingen, Germany — [5]Department of Physics and Department of Bioengineering, Northeastern University, Boston, USA

An omnipresent challenge in the analysis of complex, heterogeneous data sets is the storage, systematic retrieval and processing of interconnected data. This especially holds for interdisciplinary fields where non-standard and rapidly evolving analysis algorithms are employed. Using a semantic data model implemented in the open source software CaosDB (https://arxiv.org/abs/1801.07653), we demonstrate in case examples from cardiac research how data from experiments and simulations can be efficiently managed and processed from data acquisition to the final publication. During this data life cycle all relevant information including metadata, analysis results, documentation and software information will be stored and linked together with the raw data. This procedure guarantees that data, results and publications are documented, findable and reproducible.

SOE 4.3 Mon 12:30 H17

Big Data and Machine Learning in Astrophysics — •Karl Mannheim — Universität Würzburg, Lehrstuhl für Astronomie

Next-generation observatories such as SKA will produce data at a rate higher than can be analyzed by human scientists. Therefore, fast analysis methods such as machine learning will play a major role in the near future. Methods applied to offline data target the extraction of scientifically relevant data from the raw data, e.g. by classifying objects or recognizing morphological patterns in images or in the spectral domain. Methods applied to online data can feedback with the data aquisition system to optimize the detector performance or reduce the data volume by filtering out unusable low-quality data. Utilizing their full potential requires to advance machine learning algorithms from finding correlations to allowing causal inferences. Users and developers of ML methods from all branches of physics, astronomy, or computers science are encouraged to discuss and exchange ideas in the new DPG working group AKPIK.

SOE 5: Financial Markets and Risk Management II

Time: Monday 15:00–16:00 Location: H17

SOE 5.1 Mon 15:00 H17

How spread changes affect the order book: Comparing the price responses of order deletions and placements to trades — •Stephan Grimm and Thomas Guhr — Faculty of Physics, University of Duisburg-Essen, Lotharstr. 1, 47048 Duisburg, Germany

We observe the effects of the three different events that cause spread changes in the order book, namely trades, deletions and placement of limit orders. By looking at the frequencies of the relative amounts of price changing events, we discover that deletions of orders open the bid-ask spread of a stock more often than trades do. We see that once the amount of spread changes due to deletions exceeds the amount of the ones due to trades, other observables in the order book change as well. We then look at how these spread changing events affect the prices of stocks, by means of the price response. We not only see that the self-response of stocks is positive for both spread changing trades and deletions and negative for order placements, but also cross-response to other stocks and therefore the market as a whole. This leads to the conclusion that spread changing deletions and order placements have a similar effect on the order book and stock prices over time as trades.

SOE 5.2 Mon 15:30 H17

Order book model with herd behavior and long-range memory — •Aleksejus Kononovicius and Julius Ruseckas — Institute of Theoretical Physics and Astronomy, Vilnius University, Lithuania

Earlier we have proposed a financial ABM, which is capable of reproducing the stylized facts of absolute return [1] as well as the exact PDF and PSD of absolute return [2]. Price in our approach, similarly to other contemporary approaches, was included indirectly by using Walrasian scenario. Yet we can introduce the price directly by considering how the same agents would behave in an order book scenario. To introduce order book dynamics into our model we have took heavy inspiration from an empirically motivated order book model proposed by Kanazawa et al. [3]. The description of the full model is available on arXiv [4].

[1] A. Kononovicius, V. Gontis, Physica A 391: 1309-1314 (2012). doi: 10.1016/j.physa.2011.08.061. arXiv: 1106.2685 [q-fin.ST].

[2] V. Gontis, A. Kononovicius, PLoS ONE 9 (7): e102201 (2014). doi: 10.1371/journal.pone.0102201. arXiv: 1403.1574 [q-fin.ST].

[3] K. Kanazawa et al., PRL 120: 138301 (2018). doi: 10.1103/PhysRevLett.120.138301. arXiv:1703.06739 [q-fin.TR].

[4] A. Kononovicius, J. Ruseckas, under review. arXiv: 1809.02772 [q-fin.ST].

SOE 6: Networks: From Topology to Dynamics (joint session DY/SOE)

Time: Monday 15:00–17:45 Location: H20

SOE 6.1 Mon 15:00 H20

Inhibition induced explosive synchronization in multiplex networks — •Sarika Jalan — IIT Indore

To date, explosive synchronization (ES) is shown to be originated from either degree-frequency correlation or inertia of phase oscillators. Of late, it has been shown that ES can be induced in a network by adaptively controlled phase oscillators. We show that ES can occur in any network by appropriately multiplexing it with another layer. We devise an approach which leads to the occurrence of ES with hysteresis loop in a network upon its multiplexing with a negatively coupled (or inhibitory) layer. We discuss the impact of various structural properties of positively coupled (or excitatory) and inhibitory layer along with the strength of multiplexing in gaining control over the induced ES transition. This investigation is a step forward in highlighting the importance of multiplex framework not only in bringing novel phenomena which are not possible in an isolated network but also in providing more structural control over the induced phenomena.

SOE 6.2 Mon 15:15 H20

Coarsening dynamics of transient ferrogranular networks under influence of a horizontal magnetic field - network alignment and magnetization in experiments and simulations — Justus Miller[1], Pedro Sanchez[2], Sofia Kantorovich[2,3], and •Reinhard Richter[1] — [1]Experimentalphysik 5, Universität Bayreuth, Bayreuth, Germany — [2]University of Vienna, Vienna, Austria — [3]Ural Federal University, Ekaterinburg, 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, as well as in simulations. Analyzing the network evolution by network specific parameters like the mean number of neighbours or network efficiency we have uncovered three regimes (Kögel et al. Soft Matter **14** 2018), previously established by H. Tanaka (2000) for the viscoelastic phase separation of dynamically asymmetric mixtures.

Here we present new results for the network evolution under influence of a horizontally applied magnetic field. With increasing field strength the branched networks are more and more replaced by linear chains. We quantitatively characterize the average orientation of the network edges with respect to the direction of the applied field in experiment and simulations and explore the consequences for the magnetization curves.

SOE 6.3 Mon 15:30 H20

Asymptotically Exact Solution of the Fredrickson-Andersen Model — Koray Önder[1,2], •Till Kranz[1,2], and Matthias Sperl[2,1] — [1]Institut für Theoretische Physik, Uni Köln — [2]Institut für Materialphysik im Weltraum, DLR Köln

Kinetically constrained models describe many phenomena from opinion dynamics to amorphous solids [1]. The Fredrickson-Andersen model—a kinetically constrained lattice model—displays an ergodic to non-ergodic transition. Simulations indicate a slow two-step relaxation of dynamical correlation functions close to the transition point. We derive an asymptotically exact solution for the dynamical occupation correlation function of the Fredrickson-Andersen model on the Bethe lattice by identifying an exact expression for its memory kernel. The exact solution proves an empirical scaling relation [2] between critical exponents and allows to calculate the exponents explicitly. In addition, we propose an approximate dynamics that describes numerical data away from the critical point over many decades in time.

[1] F. Ritort and P. Sollich, Adv. Phys. **52**, 219 (2003)
[2] M. Sellitto, Phys. Rev. Lett. **115**, 225701 (2015)

SOE 6.4 Mon 15:45 H20

Assessing and improving the replication of chaotic attractors by means of reservoir computing — •Alexander Haluszczynski[1,3], Christoph Raeth[2], Ingo Laut[2], and Mierk Schwabe[2] — [1]Ludwig-Maximilians-Universität, München, Deutschland — [2]Deutsches Zentrum für Luft- und Raumfahrt, Weßling, Deutschland — [3]Allianz Global Investors, München, Deutschland

The prediction of complex nonlinear dynamical systems with the help of machine learning techniques has become increasingly popular. In particular, the so-called "reservoir computing" method turned out to be a very promising approach especially for the reproduction of the long-term properties of the system [1]. Yet, a thorough statistical analysis of the forecast results is missing. So far the standard approach is to use purely random Erdös-Renyi networks for the reservoir in the model. It is obvious that there is a variety of conceivable network topologies that may have an influence on the results. Using the Lorenz System we statistically analyze the quality of predicition for different parametrizations - both the exact short term prediction as well as the reproduction of the long-term properties of the system as estimated by the correlation dimension and largest Lyapunov exponent. We find that both short and longterm predictions vary significantly. Thus special care must be taken in selecting the good predictions. We investigate the benefit of using different network topologies such as Small World or Scale Free networks and show which effect they have on the prediction quality. Our results suggest that the overall performance is best for small world networks. [1] J. Pathak et al., Chaos, 27, 121102 (2017)

SOE 6.5 Mon 16:00 H20

Principal Eigenvector Localization in Multilayer Networks — •Priodyuti Pradhan[1] and Sarika Jalan[1,2] — [1]Complex Systems Lab, Discipline of Physics, Indian Institute of Technology Indore, Khandwa Road, Simrol, Indore-453552, India — [2]Centre for Biosciences and Biomedical Engineering, Indian Institute of Technology Indore, Khandwa Road, Simrol, Indore-453552, India

Starting with a multilayer network (MN) corresponding to a delocalized PEV, we rewire the network edges using an optimization technique such that the PEV of the rewired MN becomes more localized. The localization of an eigenvector refers to a state where few components of the vector take very high values, and rest of the components take very small values. For a two layers MN, the optimization process can be implemented in two different edge rewiring protocols; (1) by rewiring edges in both-layers or (2) by rewiring edges in only one layer. We reveal that for both the rewiring protocols, though there is an emergence of various specific structural features, the different rewiring protocols lead to a noticeable difference in the spectral properties of the optimized MN. For the both-layers rewiring protocol, PEV is sensitive to a single edge rewiring in the optimized MN, and however, interestingly, we get rid of this sensitivity of PEV for the single-layer rewiring protocol. This sensitivity in the localization behavior of PEV is accompanied by the second largest eigenvalue lying very close to the largest one. Furthermore, analysis of MNs constructed using real-world social and biological data show a good agreement with the simulation results for model MN.

15 min. break

SOE 6.6 Mon 16:30 H20

Topology vs. Node Dynamics in Collective Adaptation to Risk — Matthew Grobis[1], Colin Twomey[2], Joseph Bak-Coleman[1], •Winnie Poel[3,4], Bryan Daniels[5], Pawel Romanczuk[3,4], and Iain Couzin[6,7] — [1]Princeton University, USA — [2]University of Pennsylvania, USA — [3]Humboldt Universität zu Berlin — [4]Bernstein Center for Computational Neuroscience Berlin, Germany — [5]Arizona State University, USA — [6]Max Planck Institute for Ornithology, Germany — [7]University of Konstanz, Germany

Our research focuses on the mechanism used by large animal groups to reliably collectively process information on external threats like predation. Specifically, we are interested in the role of an individual's internal state vs. the structure of the group in collective reaction to perceived risk. Using a generic contagion model [1], we study behavioral response cascades in fish schools based on empirically inferred visual interaction networks [2]. We aim to uncover if and how the spatial configuration of the group (i.e. structure of its visual interaction network) and the individual response parameters affect the collective responsiveness.

[1] Dodds PS, Watts DJ (2005) Journal of Theoretical Biology 232(4):587-604
[2] Rosenthal et Al. (2015) PNAS 112(15):4690-4695

SOE 6.7 Mon 16:45 H20

Structure and dynamics of non-normal networks — •Malbor Asllani — University of Limerick, Limerick, Ireland

Network theory has been a groundbreaking research field in science for the last 20 years, conceivably the only one that could glue together disparate and even contrasting disciplines such as physics, economy, biology or sociology. A network materializes the complex interactions between the composing entities of large systems, it thus defines the natural and structural backbone for describing complex systems, which dynamics is unavoidably bound to the network properties. Based on a detailed study involving a large set of empirical networks arising from a wide spectrum of research fields, we claim that strong non-normality is indeed a universal property in network science [1]. Dynamical processes evolving on non-normal networks exhibit a peculiar behavior, initial small disturbances can undergo a transient phase and be strongly amplified although the system is linearly stable [2]. We hence propose several models to generate complex non-normal networks to explain the origin of such property. Because of the non-normality of the networked support, the comprehension of the dynamical properties goes beyond the classical linear spectral methods, while we show that the pseudo-spectrum is able to capture such behavior. This response is very general and it challenges our understanding of natural processes grounded in real networks, as we illustrate in the Generalised Lotka-Volterra model.

[1] M. Asllani and T. Carletti, Sci. Adv. 4, eaau9403 (2018). [2] M. Asllani and T. Carletti, Phys. Rev. E 97, 042302 (2018).

SOE 6.8 Mon 17:00 H20

Chimera States in Networks of Type-I Morris-Lecar Neurons — •Philipp Hövel[1], Ali Calim[2], Mahmut Ozer[3], and Muhammet Uzuntarla[2] — [1]School of Mathematical Science, University College Cork, Ireland — [2]Department of Biomedical Engineering, Bulent Ecevit University, Turkey — [3]Department of Electrical and Electronics Engineering, Bulent Ecevit University, Turkey

Chimeras are complex spatio-temporal patterns that emerge as coexistence of both coherent and incoherent groups of coupled dynamical systems. Here, we investigate the emergence of chimera states in nonlocal networks of type-I Morris-Lecar neurons coupled via chemical synapses. This constitutes a more realistic neuronal modeling framework than previous studies of chimera states, since the Morris-Lecar model provides biophysically more relevant control parameters to describe the activity in actual neural systems. We explore systematically the transitions of dynamic behavior and find that different types of synchrony appear depending on the excitability level and nonlocal network features. Furthermore, we map the transitions between incoherent states, traveling waves, chimeras, synchronized states and global amplitude death in the parameter space of interest. This work contributes to a better understanding of biological conditions giving rise to the emergence of chimera states in neural medium.

Reference: A. Calim, M. Ozer, P. Hövel, M. Uzuntarla, Phys. Rev. E (2018) in print.

SOE 6.9 Mon 17:15 H20

Terminal Transient Phase of Chimera States — •Thomas Lilienkamp[1] and Ulrich Parlitz[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Nonlinear Dynamics, Georg-August-Universität Göttingen, Germany

In spatially homogeneous systems regions with regular and coherent motion may coexist with regions where irregular and incoherent dynamics occurs. In many cases, chimera states are actually chaotic transients which self-terminate abruptly e.g. towards the completely coherent state. Recent studies of chaotic transients in various systems show, that although the process of self-termination seems to be abrupt [1], a particular final transition phase in state space could be verified, called the "Terminal Transient Phase" [2, 3]. Using small but finite perturbations it was shown, that the state space structure is significantly different in this transition zone. We detected this behavior also in different spatially extended systems which exhibit chimera states. Furthermore, the spatial distribution of perturbations which have a significant impact on trajectories just before the collapse turns out to be correlated with the state of the system. Thus, before its self-termination the chimera state is mostly "vulnerable" only at specific regions of the spatial domain.

[1] T. Lilienkamp, J. Christoph, and U. Parlitz. Phys. Rev. Lett. 119, 054101 (2017)

[2] T. Lilienkamp and U. Parlitz. Phys. Rev. Lett. 120, 094101 (2018)

[3] T. Lilienkamp and U. Parlitz, Phys. Rev. E 98, 022215 (2018)

SOE 6.10 Mon 17:30 H20

Synchronization of time-varying networks with coupling delays — •Otti D'Huys[1], Javier Rodríguez-Laguna[2], Manuel Jiménez-Martín[2], and Elka Korutcheva[2] — [1]Department of Mathematics, Aston University, B4 7ET Birmingham, United Kingdom — [2]Departamento de Física Fundamental, UNED, Spain

We study the effect of a fluctuating topology in delay-coupled networks. Such network fluctuations are common, for instance, between interacting neurons, or networks modeling social interactions.

We concentrate on the synchronization properties of chaotic maps. The topology fluctuates between an ensemble of small-world networks. The dynamics is characterized by three timescales: the internal time scale of the node dynamics, the connection delay along the links, and the timescale of the network fluctuations. When the network fluctuations are faster than the coupling delay and the internal time scale, the synchronized state can be stabilized by the fluctuations. As the network time scale increases, the synchronized state becomes unstable when both time scales collide.

We complement these results with an analytical theory in the linearized limit. Two limit cases allow an interpretation in terms of an 'effective network': When the network fluctuations are much faster than the internal time scale and the coupling delay, the effective network topology is the average over the different topologies. When coupling delay and network fluctuation time scales collide, the effective topology is the geometric mean over the different topologies.

SOE 7: Social Systems, Opinion and Group Formation I

Time: Monday 16:00–17:15 Location: H17

SOE 7.1 Mon 16:00 H17

Investigating viral dynamics using cellular automata on mobility networks — •Rory Humphries, Philipp Hövel, and Kieran Mulchrone — School of Mathematical Sciences, University College Cork

The prevalence of anti-biotic resistant bacteria is increasing at a rate outpacing the development of new effective drugs. Developing new ways of tackling epidemics is an important consideration in the future as prevention may become more important than cure. The goal of this contribution is to model the spatial path that a disease is most likely to follow, and to identify areas to be hardest hit. A SEIR model realized as a cellular automaton is investigated. One major challenge for modelling viral dynamics on large spatial scales is the implementation of the movement of individuals, a major facilitator of the spread of disease. Thus, a focal point of this contribution addresses the resulting complex spatial dynamics. For the description of mobility, we consider Lévy processes as they may provide a quite natural model for the random movement of people across all spatial scales, by allowing for more localised diffusive dynamics as well as long range jumps.

SOE 7.2 Mon 16:15 H17

Social influence with recurrent mobility and multiple options — •Attila Szilva[1] and Jérôme Michaud[2] — [1]Department of Physics and Astronomy, University of Uppsala, 752 37 Uppsala, Sweden — [2]Department of Physics and Astronomy, University of Uppsala, 752 37 Uppsala, Sweden and Department of Sociology, University of Uppsala, 751 20 Uppsala, Sweden

In this paper, we discuss the possible generalizations of the social influence with recurrent mobility (SIRM) model [Phys. Rev. Lett. 112, 158701 (2014)]. Although the SIRM model worked approximately satisfying when U.S. election was modeled, it has its limits: it has been developed only for two-party systems and can lead to unphysical behavior when one of the parties has extreme vote share close to 0 or 1. We propose here generalizations to the SIRM model by its extension

for multiparty systems that are mathematically well-posed in case of extreme vote shares, too, by handling the noise term in a different way. In addition, we show that our method opens alternative applications for the study of elections by using an alternative calibration procedure and makes it possible to analyze the influence of the *free will* (creating a new party) and other local effects for different commuting network topologies.

SOE 7.3 Mon 16:30 H17

Argument Exchange Dynamics in a Population with Divergent Mindsets — •Sven Banisch, Tat Dat Tran, and Eckehard Olbrich — Max-Planck Institut für Mathematik in den Naturwissenschaften, Leipzig

We present a simple model of argument communication, which allows to analyze the effects of different world views. In the model, agents exchange beliefs about facts. Agents evaluate these facts and form an attitudinal judgement on an issue through their cultural glasses. Facts may, if believed, contribute positively or negatively to this judgement in a way borrowed from expectancy value theory. The interaction probability of two agents depends on two types of homophily: one based on the difference of their attitudes and the other one based on whether they belong to the same culture. This allows for an analysis of the effects that the interplay of opinion homophily and cultural segregation may have on the dynamics of opinion formation by argument persuasion. We analytically show that cultural diversity may play a depolarizing role in argument exchange processes.

SOE 7.4 Mon 16:45 H17

Accelerating dynamics of the public discussion — •Philipp Lorenz-Spreen[1], Sune Lehmann[2], and Philipp Hövel[3] — [1]Max Planck Insitute for Human Development, Berlin, Germany — [2]Technical University of Denmark, Lyngby, Denmark — [3]University College Cork, Cork, Ireland

With news pushed to smart phones in real time and social media reactions spreading across the globe in seconds, the public discussion can feel accelerated and temporally fragmented. In longitudinal datasets across various domains, covering a range of time spans, we find significantly increasing gradients and shortened periods in the trajectories of public attention.

Is this a consequence of recent developments or the inevitable conclusion of the way information is disseminated and absorbed by the public? Our findings support the latter hypothesis.

Using a simple mathematical model of competing topics, we are able to explain the empirical data remarkably well. Our modeling suggests that the accelerating ups and downs of content popularity are driven by increasing rates of creation and consumption of cultural items. The interplay of the ephemerality of attention and the competition for novelty causes growing turnover rates and shorter attention spans.

SOE 7.5 Mon 17:00 H17

Change points, memory and epidemic spreading in temporal networks — •Tiago Peixoto[1] and Laetitia Gauvin[2] — [1]University of Bath, UK — [2]ISI Foundation, Turin, Italy

Dynamic networks exhibit temporal patterns that vary across different time scales, all of which can potentially affect processes that take place on the network. However, most data-driven approaches used to model time-varying networks attempt to capture only a single characteristic time scale in isolation — typically associated with the short-time memory of a Markov chain or with long-time abrupt changes caused by external or systemic events. Here we propose a unified approach to model both aspects simultaneously, detecting short and long-time behaviors of temporal networks. We do so by developing an arbitrary-order mixed Markov model with change points, and using a nonparametric Bayesian formulation that allows the Markov order and the position of change points to be determined from data without overfitting. In addition, we evaluate the quality of the multiscale model in its capacity to reproduce the spreading of epidemics on the temporal network, and we show that describing multiple time scales simultaneously has a synergistic effect, where statistically significant features are uncovered that otherwise would remain hidden by treating each time scale independently.

SOE 8: Social Systems, Opinion and Group Formation II

Time: Monday 17:15–18:30 Location: H17

SOE 8.1 Mon 17:15 H17

Towards realistic models for social feedback in opinion dynamics — •Felix Gaisbauer, Sven Banisch, and Eckehard Olbrich — Max Planck Institute for Mathematics in the Sciences, Leipzig, Germany

In [1] a new mechanism to explain polarization phenomena in opinion dynamics based was proposed, which was based on social positive or negative feedback on expressed opinions. We showed that the opinion dynamics can be described as reinforcement learning in a coordination game and derived the structural condition on the network - the existence of more than one cohesive set - for the co-existence of different opinions in the network. In the present work we extend the approach by introducing costs for opinion expression, which means that opinions are only expressed if the agents are sufficiently convinced. Therefore, not every agent will express her opinion. Moreover, agents learn not only by the feedback on their expressed opinions, but also by the opinions expressed by others. We study how these additions affect polarization in different networks. Furthermore, we show that in this case - contrary to the original model - a small cohesive group of strongly convinced agents can convince a larger group of less convinced agents with an initially different opinion.

[1] S. Banisch & E. Olbrich (2018) Opinion polarization by learning from social feedback, The Journal of Mathematical Sociology, DOI: 10.1080/0022250X.2018.1517761

SOE 8.2 Mon 17:30 H17

Inferring follower-followee relations from presence data. Manta Rays case study. — •Juan Fernández-Gracia[1], Jorge P. Rodríguez[1], Lauren Peel[2], Konstantin Klemm[1], Mark Meekan[2], and Víctor M. Eguíluz[1] — [1]Instituto de Física Interdisciplinar y Sistemas Complejos IFISC (CSIC-UIB), E07122 Palma de Mallorca, Spain — [2]Australian Institute of Marine Science, Indian Ocean Marine Research Centre (IOMRC), University of Western Australia (M470), 35 Stirling Highway, Crawley, WA 6009, Australia

Social interactions are ubiquotous in groups of animals, including humans. These interactions might be of different nature, e. g. competitive, mutualistic, kinship, etc; and their global structure is naturally studied with the tools of complex network theory. Here we propose a method to extract follower-followee networks from presence data at a certain location. The method is based on the Kolmogorov-Smirnov distance between the distribution of waiting times between the consecutive presence of an individual i followed by the presence of j in the vicinity of a particular location and its conjugate distribution, i.e., j's presence followed i's. Using this method we construct the follower-followee network of manta-rays and characterize mantas in terms of their position on this network, paying attention to sex and size.

SOE 8.3 Mon 17:45 H17

It Don't Mean a Thing, If It Ain't Got That Swing: Unraveling a Musical Mystery by Scientific Means? — •George Datseris[1,2], Annika Ziereis[3], Thorsten Albrecht[3], York Hagmayer[3], Viola Priesemann[1,2], and Theo Geisel[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization — [2]Department of Physics, Georg-August-University Goettingen — [3]Georg-Elias-Mueller Institute for Psychology, Georg-August-University Goettingen

The so-called swing feeling in jazz performances has puzzled musicologists and jazz critics for decades. For a long time it was believed that one can feel it, but one cannot explain it. More recently discussions focused on the role of microtiming deviations (MTDs, temporal deviations below the phrase level); some musicologists have claimed that they are essential for the swing feeling.

Our group has analyzed these MTDs in detail and found e.g. differences between swinging jazz and rock/pop music on time scales typically below 2 bars. Moreover, to answer whether they are relevant for the swing feeling we carried out an online survey using jazz recordings in which we had systematically manipulated MTDs - exaggerating, deleting, and inverting them. We found that the presence of microtiming deviations is not essential for the "swing" feeling as ver-

sions without microtiming deviations were preferred, in contrast to the common belief of many musicians and musicologists.

SOE 8.4 Mon 18:00 H17

Growth and ergodicity breaking in ecosystems and social systems — •Jan Nagler — Frankfurt School

As highlighted in a recent perspective article [Science 359: 738, 2018], in ecology exact predictions are extremely challenging. In the presentation, we ask how do species evolve in environments with asymmetric fluctuating temperature profiles. We study how natural selection do not lead to adaption to the mean temperature but to a value that is shifted and given by the skewness of the temperature profile (and also by the fitness function of the species). This prediction is derived from first principles and first results are presented in nematodes (in vitro). More generally, we discuss effects from ergodicity breaking for evolutionary game theory [PRL 120: 058101, 2018], coupled ecosystems and for climate change.

SOE 9: Economic Models

Time: Tuesday 9:30–11:30 Location: H17

SOE 9.1 Tue 9:30 H17

How exclusive competition promotes discrimination — •Gorm Gruner Jensen and Stefan Bornholdt — Institut für Theoretische Physik, Universität Bremen

Some game theoretical models have been proposed to illustrate how social discrimination could be the consequence of different groups getting stuck in different Nash equilibria due to self-perpetuating collective reputation [1,2]. While these models show that multiple equilibria are possible, they don't describe any interactions between the reputations of different groups, and it is therefore left as an open question how their historic events lead to different equilibria in the first place. Here we explore a variation of the theory of collective reputation, in which agents are not evaluated on whether their reputation is good, but rather whether it is better than that of their peers. The introduction of this element of exclusive competition is inspired by recent results from evolutionary game theory suggesting that discrimination is more likely to emerge through spontaneous symmetry-breaking in highly competitive environments [3].

[1] J. Tirole, The Review of Economic Studies **63**, 1 (1996). URL https://doi.org/10.2307/2298112

[2] J. Levin, The B.E. Journal of Theoretical Economics **9** (2009), https://doi.org/10.2202/1935-1704.1548

[3] G.G. Jensen, S. Bornholdt, Social evolution of structural discrimination, arXiv:1703.06311

SOE 9.2 Tue 10:00 H17

Poverty Dynamics — •Amit Chattopadhyay[1], Iain Rice[2], and T Krishna Kumar[3] — [1]Aston University, Mathematics, Birmingham, B4 7ET, UK — [2]Arden University, Coventry, CV3 3RD, UK — [3]Rockville-Analytics, Rockville, MD 20850, USA

Economic inequality has been conventionally measured against a unique poverty line; those below this line are deemed poor and those above it, not so! Economists are well aware of the pitfall of such a strict line of demarcation, all based on an exogenous number that may be misleading as well. Departing from such a subjective inequality measure, here we have modeled the largest available dataset (India) using advanced machine learning architecture, over all three expenditure modes (basic food, other food and non-food) that are mutually connected, to avail information on multivariate income distribution functions (PDFs). Independent agent-based stochastic models of trade were then used to validate these PDFs, where trade in assets was only allowed between agents with incomes exceeding a self-consistent mean income over the dynamically evolving trade market, thereby substituting an exogenous poverty line with a data-objectified economic threshold. Together with recent publications (EPL 91, 58003; PRE95, 023109), we have established an alternative probabilistic measure of inequality that is free of personal bias.

SOE 9.3 Tue 10:30 H17

Stability of a time-homogeneous system of money and anti-money and multi-flavor moneys — •Julian Stein and Dieter Braun — Systems Biophysics LMU Munich

One source of financial instability might be the creation of money [1] also leading to non-local transfers of wealth (Cantillon effect) and a loss of economic memory [2]. Motivated by an analogy to particle physics, time-homogeneity can be imposed on monetary systems to solve the associated problems. As a result, full reserve banking is implemented by a two-currency system of non-bank (money) and bank assets (antimoney) [3]. Payments are either made by passing on money or receiving antimoney at respective price levels. Liquidity is provided by the simultaneous transfer of money and antimoney from seller to buyer at a negotiated liquidity price. Thus interest rates and credit are implemented by a varying price for liquidity. We show that the system exhibits behavior similar to the prevailing monetary system for good and credit shocks in an agent-based model economy with constraints on individual debt levels.

To set up a monetary system in which a credit lender is liable for his/her granted credits, we extend the the money-antimoney system to a flavor-money and antimoney system. In this system, every acting subject is endowed with the same amount of unique money and antimoney. We argue that this system might show increased robustness under hazardous agent behavior and test its stability.

[1] Am Econ Rev 102 (2012) [2] New J Phys 16, 033024 (2014), [3] Physica A 290, 491 (2001)

SOE 9.4 Tue 11:00 H17

Human Nature synchronizes and limits the Industrial Society per Capita — •Hans Danielmeyer and Thomas Martinetz — INB Uni Lübeck, Germany

During the Cold War's longest peace on G8 level soil the world's average existential conditions improved by an order of magnitude. Yet the lower half owns generally nothing above debt, and 93% of all assets are owned by the top 10%. This inequity caused the electorate's current anger at democracy. Nevertheless, we predict a possibly peaceful future for China, the USA, Russia, Germany, Japan, and the UK. Their original innovation was strong enough for pushing the male and female maturation programs along their inherited dynamic limits (Springer Link Jan. 19, 2018 or inb.uni-luebeck.de). This indestructible and socially uniting master plan replaced implicitly Adam Smith's accumulation of destructible wealth as socially dividing goal. Four new variables and their directly measured inherited time constants are all but immune even to world wars: annual working and spare time, the best outputs per capita above all disasters, the associated G7 life style's life expectancy, the human generation gap, and a human adaption time of 62 years that links two generations. The natural theory is analytically exact, needs no extrapolation, and is as self-consistent as human maturation.

15 min. break

SOE 10: Evolutionary Game Theory (joint SOE/BP/DY) (joint session SOE/BP)

Time: Tuesday 11:30–12:30 Location: H17

SOE 10.1 Tue 11:30 H17

Evolutionary dynamics of multiple games — •Vandana Revathi Venkateswaran and Chaitanya S. Gokhale — Department of Evolutionary Theory, Max Planck Institute for Evolutionary Biology, August-Thienemann-Str. 2, 24306 Plön

Phenomena from bacterial population dynamics to evolution of social behaviour are being successfully described using evolutionary game theory. However, it has typically focused on a single game describing the interactions between individuals. Organisms are simultaneously involved in many intraspecies and interspecies interactions. Therefore, one should move from single games to multiple games. However, the interactions in nature involve many players. Shifting from two player games to multiple multiplayer games yield different interesting dynamics and help us get closer to naturalistic settings. A complete picture of multiple game dynamics (MGD), where multiple players are involved, was lacking. We present a complete and general method to study multiple games with many strategies and players, all at once. We provide a concise replicator equation, and analyse its resulting dynamics. We show that if the individual games involved have more than two strategies, then the combined dynamics cannot be understood by looking only at individual games. Moreover, in the case of finite populations, we formulate and calculate a basic and useful stochastic property, fixation probability. Our results reveal that even as interactions become increasingly complex, their properties can be captured by relatively simple concepts of evolutionary game(s) theory.

SOE 10.2 Tue 12:00 H17

Control of biodiversity in evolutionary dynamics: extension to higher dimensions — •Jens Christian Claussen — Department of Mathematics, Aston University, Birmingham B4 7ET, U.K.

Cyclic dominance, as observed in biology and socio-economic systems, has frequently been investigated in its role towards stabilization of diversity of strategies [PRL 100, 058104], and it has been shown that the introduction of a parameter in the payoff matrix can lead to a stabilization of the symmetric state of coexistence. Recently, we had introduced a feedback control method which utilizes a feedback term derived from a conserved property of motion of the case of a neutral oscillation. This mechanism was discussed, analyzed and numerically demonstrated explicitly for the cyclic rock-paper-scissors game. Here, we discuss the generalization to cyclic dominance of M strategies and their implications. First, it is observed that the straightforward generalization leads again to payoff functions with polynomial degrees up to third order, multiplied by the feedback term which in this case is of order M, resulting in characteristic polynomials of order 2(M + 2), compared to order 4 without control, prohibiting closed eigenvalue expressions even for the fixed point stability. To circumvent this, alternative feedback functions are introduced which allow for lower orders. Finally, we discuss the applicability of this approach.

SOE 11: Award Session: Young Scientist Award for Socio-and Econophysics (YSA)

The Young Scientist Award for Socio- and Econophysics of the German Physical Society (DPG) recognizes outstanding original contributions that use physical methods to develop a better understanding of socio-economic problems.

Time: Tuesday 14:00–16:00 Location: H17

Invited Talk SOE 11.1 Tue 14:00 H17

From individual models of attitude change to patterns and dynamics of opinion landscapes — •Jan Lorenz — Uni Bremen, Bremen, Germany — Jacobs University, Bremen, Germany

We model the dynamics of attitude formation through social interaction in a large society. We consider attitudes on a one dimensional scale which represents either emotional valence towards a certain object or concept (e.g. "How good or bad is religion?"), the degree to which a certain value is important for a person, political left-right self-placement, or adherence to certain social norms (e.g. "Murder is to be punished with death."). Individual attitude change during interaction with others is modeled with respect to a reinforcement theory, an information processing theory, a social judgment theory, and a polarity effect. We will answer the questions to what extend these indivual mechanisms contribute to the societal phenomena of extremal consensus, moderate consensus, polarization, fractionalization, maintenance of diversity, and cyclic behavior.

Presentation of the Young Scientist Award to the Awardee.

Prize Talk SOE 11.2 Tue 15:00 H17

The Dynamics of Social Conventions: From Names to Cryptocurrencies — •Andrea Baronchelli — City, University of London (UK)

How do conventions emerge and evolve in complex decentralised social systems? This question engages fields as diverse as sociology, economics, cognitive science and network science. Various attempts to solve this puzzle pre-suppose that formal or informal institutions are needed to facilitate a solution. The complex systems and statistical physics approach, by contrast, hypotheses that such institutions are not necessary in order for social consensus to form. In this talk, I will discuss theoretical and experimental results that demonstrate the spontaneous creation of universally adopted social conventions and clarify how the properties of the social network control the dynamics of norm formation. Then, I will discuss how social norms change, showing how historical data and lab experiments indicate that abrupt transitions between competing norms do not require the intervention of a centralised authority. Finally, I will present some recent results on the modelling of the cryptocurrency market, where users conventionally attribute value to electronic tokens. Overall, these results clarify the processes of social coordination and collective behaviour change and can help better understand the dynamics of such phenomena in online and offline social media as well as aid the design of effective policies to foster desirable collective behavioural shifts, for example to contrast climate change.

After the YSA award session, there is an informal get-together with posters, beer, and pretzels.

SOE 12: Poster

Posters can - and should - be on display the whole day. Posters 13-17 accompany the Focus Session on Dynamics of Multilayer Networks.

Time: Tuesday 16:00–19:00 Location: Poster A

SOE 12.1 Tue 16:00 Poster A

Statistical patterns of Lithuanian municipality elections — •Aleksejus Kononovicius — Institute of Theoretical Physics and Astronomy, Vilnius University, Lithuania

In this contribution we will present an analysis of statistical patterns observed during Lithuanian municipality elections. We consider parties' vote share at the polling station level. We perform a comparison across the different municipalities with an aim to understand whether the vote share samples could have come from the same distribution. This approach is based on our earlier works in which we have considered Lithuanian parliamentary elections [1,2].

[1] A. Kononovicius, Complexity 2017: 7354642 (2017). doi: 10.1155/2017/7354642. arXiv: 1704.02101 [physics.soc-ph].

[2] A. Kononovicius, APPA 133 (6): 1450 (2018). doi: 10.12693/APhysPolA.133.1450. arXiv: 1709.07655 [physics.soc-ph].

SOE 12.2 Tue 16:00 Poster A

The Hidden Physics of Human Progress and Poverty — •Stephen I. Ternyik — POB.201 D-82043 Munich

The economic pathologies of current acute problems in social systems evolution do point to a very unhealthy state of the body economic; the global economy is in a dismal condition. Inequitable distribution of labor and income, extreme monetary excesses, highly growing debts, spreading bureaucratic planning and accumulating ecological externalities are the widely circulating diseases, which seem to be insoluble symptoms of a deeply sick economy. The Sisyphean root cause (history repeating) of these joint economic maladies is the gradually exceeding volume of economic rent (unearned income), which is extracted from the working body economic. This economic version of phlebotomy (blood-letting) seems to occur in cyclical patterns (slowdown after boom), when financial investments are massively directed into physical assets (land location value, real estate), which reduces vital liquidity for further economic growth. The only 'medical' remedy against this cyclical phenomenon is to tax economic rent and to recapture it as public revenue.

SOE 12.3 Tue 16:00 Poster A

Deep Reinforcement Learning in World-Earth-System Models Exploring Sustainable Behavior — •Felix Strnad[1,2], Wolfram Barfuss[1], Jonathan F. Donges[1,3], and Jobst Heitzig[1] — [1]Potsdam Institute for Climate Impact Research, Germany — [2]Department of Physics, University of Göttingen, Germany — [3]Stockholm Resilience Centre, Stockholm University, Sweden

Pathways to global sustainability need to account for critical feedbacks between the socio-cultural World and the biophysical Earth system. These feedbacks may require novel, yet undiscovered global policies for the governance leading towards a safe and just operating space. Currently the combination of agent-based modeling, reinforcement learning and deep neural networks, called Deep Reinforcement Learning (DRL), has become increasingly popular. DRL-algorithms have been shown to learn policies up to super-human performance in a variety of different environments.

In this work, we apply DRL within stylized World-Earth models. We developed an agent that is able to act and learn in variable manageable non-linear complex environments. We trained our agent with a deep Q-network (DQN) using experience replay and periodically updated target networks. We systematically investigated the effect of various parameters for the learning success, such as the discount factor, the training data set size or the exploration-exploitation trade-off. By using this optimized parameter set, we find that our agent is able to learn novel policies towards sustainable regions in multiple conceptual models of the World-Earth system.

SOE 12.4 Tue 16:00 Poster A

Mapping mathematical models for language shift to linguistic reality — •Katharina Prochazka[1,2], Michael Leitner[3], and Gero Vogl[1] — [1]Fakultät für Physik & VDSP, Universität Wien, 1090 Wien, Austria — [2]Institut für Slawistik, Universität Wien, 1090 Wien, Austria — [3]Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, 85748 Garching, Germany

When people stop speaking one language and adopt another, this is called language shift. In language shift, the "new" language spreads while the "old" one retreats. To describe this process and see how and why it happens, mathematical models can be used. These models are often based on the analogy between the spread of particles (physical diffusion) and languages (language diffusion) and comprise differential equations (macroscopic reaction–diffusion systems) as well as agent-based approaches (microscopic models as in [1]).

In this contribution, we focus on the interpretation of such models: How do abstract parameters correspond to what is actually going on during language shift? What can be learned from models which do not incorporate empirical data? And on the other hand: Which model is appropriate under which conditions?

More concretely, we explore the modelling of different processes of language shift by using empirical data from two examples in Austria and Hungary. For these cases, we show how the available data and conditions such as geographical structure inform the choice of a certain model.

[1] K. Prochazka and G. Vogl, PNAS 114, 4365 (2017)

SOE 12.5 Tue 16:00 Poster A

From utility functions to many-particle Hamiltonians (and back). — •Michael Schnabel and Daniel Diermeier — University of Chicago, Chicago, USA

As a simple model of binary opinion formation we consider a population of N interacting agents that can select among two different states. We assume that the individual choices are made based on maximizing some underlying utility function that depends on the current distribution of opinions in the population, but otherwise can have arbitrary shape. The resulting stationary distribution of opinions can be written as a Gibbs-Boltzmann distribution with an effective Hamiltonian that describes the interactions occurring at the microscopic scale. We present a method how to obtain the interaction coefficients and describe their scaling behavior as a function of the population size N. Moreover we derive a criterium to tell for what type of utility function the pairwise approximation will be applicable (or not).

SOE 12.6 Tue 16:00 Poster A

Demand Responsive Ride Pooling: Theory and Simulation — •Felix Jung[1,2] and Stephan Herminghaus[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Nonlinear Dynamics, University of Göttingen, Germany

Undeniably one of the most pressing challenges of our time is the question how human mobility can be made sustainable. A possible way to reduce environmental impact is to increase the average ratio of the number of persons being transported to the number of vehicles utilized for the task. This has the potential to not only reduce the impact during operation (i.e. burning of fossil fuels) but also during manufacturing of the vehicles. On a public transport scale this type of operation is termed *ride pooling*: Persons expressing a desire to travel in similar spatial directions get assigned to a common vehicle, reducing the parallel travel of multiple vehicles.

To predict the key parameters of demand responsive ride pooling systems and to estimate their market potential a corresponding mean field theory has been developed [1], which is investigated here by means of computer simulation of such systems [2].

[1] Herminghaus, Transportation Research Part A **119** (2019)

[2] Sorge et al., Proceedings of the 2015 Winter Simulation Conference

SOE 12.7 Tue 16:00 Poster A

Evaluation of Real Life Taxi Data regarding Demand Responsive Ride Pooling — •Michael Sternbach[1,2] and Stephan Herminghaus[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Georg-August-Universität Göttingen Institut für Nichtlineare Dynamik

One of the most important upcoming challenges of our society are the climate change and shortage of resources, such as energy and clean air. Motorized individual traffic (MIV), which is particularly wasteful

in this respect, can potentially be outcompeted by (more parsimonious) ride pooling systems. To achieve this goal, the latter must be provided economically and with sufficient customer comfort. We investigate this possibility by feeding real life taxi data to a demand responsive ride pooling model [1]. We simulate attempts to serve the incoming requests, which in real life were serviced by taxis, in a way such as to pool as many rides as possible under suitable constraints on the tortuosity of the route. This is used to quantify the poolability of the corresponding taxi requests. Optimization of operation under variable cost functions is investigated.
[1] Herminghaus, Transportation Research Part A **119** (2019)

SOE 12.8 Tue 16:00 Poster A

Continuous increases or decreases in city sizes observed in Japanese telephone directory data — •Takaaki Ohnishi[1], Takayuki Mizuno[2], and Tsutomu Watanabe[1] — [1]The University of Tokyo, Tokyo, Japan — [2]National Institute of Informatics, Tokyo, Japan

In order to investigate urban development and decline, we empirically study the number of shops and facilities $x(t)$ at municipality level in Japan observed in fixed-line telephone directory data from 2011 to 2017. Observation of the scatter plot for $x(t)$ and the annual growth rates $r(t) = \log(x(t+1)/x(t))$ supports that $r(t)$ decrease with its size $x(t)$. Both Kendall rank correlation coefficient and Pearson correlation coefficient show significant negative correlation between them, indicating deviations from Gibrat's law. This result is similar to what is found for population growth. There is significant positive correlation between two successive annual growth rates $r(t)$ and $r(t+1)$, implying that cities with large (small) $r(t)$ tend to be larger (smaller) in the next year. Then, we evaluate the conditional probability of size increase (decrease) in the next size change after n successive size increase (decrease) and find that the probability is significantly larger than 0.5. As n becomes larger, the probability gradually increases. Probabilities of successive negative size changes are slightly higher than that of positive size changes. We observe these properties even for each industry as well as for each prefecture. These findings suggest that city sizes are more likely to continue increasing or decreasing, which help to characterize urban dynamics.

SOE 12.9 Tue 16:00 Poster A

Validation of dynamic social network models by real-world network data — •Jakob Lochner[1,2], Jobst Heitzig[1], Marc Wiedermann[1], Jonathan Donges[1], and Jürgen Vollmer[2] — [1]Institut für Klimafolgenforschung, Potsdam, Deutschland — [2]Institut für Theoretische Physik, Leipzig, Deutschland

Everyday experience suggest that individual opinions and identities play an important role for establishing or aborting social relations. Such processes are partially implemented in conceptual dynamic network models, e.g., the adaptive voter model (Holme et al., 2006). Our study aims at a validation of these models and their underlying assumptions about the feedbacks between individual opinions and the topology of the underlying network. To this end we perform a statistical regression analysis of behavior and network data collected at MIT in 2008. The data was recorded by sensors in mobile phones that were given to 80 students. The phones measured proximity to other phones via Bluetooth, and collected communication data from calls and messages. Furthermore the students submitted questionnaires about health, political interest, musical preferences and relationships to other participants. The study monitors their behaviour and opinions over a total period of approximately nine months. We show that, our regression analysis allows to identify underlying social processes like homophily. Forthcoming work will address data from larger social networks and compare it to proxy data generated by numerical implementations of specific models.

SOE 12.10 Tue 16:00 Poster A

Dynamics of interacting generalized tipping elements on complex networks — •Jonathan Krönke[1,2], Nico Wunderling[1,2,3], Jonathan F. Donges[1,4], and Ricarda Winkelmann[1,2] — [1]Earth System Analysis, Potsdam Institute for Climate Impact Research, Potsdam, Germany — [2]Institute of Physics, Potsdam University, Potsdam, Germany — [3]Department of Physics, Humboldt University, Berlin, Germany — [4]Stockholm Resilience Centre, University of Stockholm, Stockholm, Sweden

Critical transitions have increasingly become a topic of interest in the last decades and many systems with critical transitions have been identified in nature and society (Scheffer, et al. 2009). Such phenomena are often described as tipping elements (Lenton, et al. 2008). Recently the focus of attention has also shifted to the interactions of tipping elements (Brummit et al., 2015, Dekker et al., 2018) and the potential of cascading tipping that originates from such interactions (Steffen, et al. 2018).

Here, we study complex networks of generalized tipping elements as linearly coupled systems of ordinary differential equations. We investigate cascading effects in different network topologies and find that network topologies with a higher clustering tend to be more vulnerable to tipping cascades. Furthermore we investigate how this could be a destabilizing mechanism in spatially extended systems.

SOE 12.11 Tue 16:00 Poster A

Edge directionality properties in complex spherical networks — •Frederik Wolf[1,2], Catrin Kirsch[1], and Reik Donner[1,3] — [1]Potsdam Institute for Climate Impact Research, Research Domain 4 — [2]HU Berlin, Department of Physics — [3]Hochschule Magdeburg-Stendal, Department of Water, Environment, Construction and Safety

Spatially embedded networks have recently attracted increasing attention. In their context, new types of network characteristics have been introduced recently which explicitly take spatial information into account. Among others, edge directionality properties have gained particular interest.

In this work, we introduce the mean edge direction, local anisotropy and local mean angle as new broadly applicable geometric network measures for spatial networks. Subsequently, we illustrate characteristic features of these edge directionality measures by applying them to two different examples of real-world spherical networks describing air transportation and global trade.

In the air transportation network, we identify distinct traffic zones in Europe, North and South America as well as in East Asia. In the world trade network, we confirm the important role of the European Union for global trade by identifying convergent edge directionality pattern. In addition, we reveal different roles of various countries in the world trade system by comparing import and export networks. The employed method provides a framework to utilize the geographical information encoded in spatially embedded networks and thus contributes to a better understanding of real-world networks using a geometric approach.

SOE 12.12 Tue 16:00 Poster A

Network reconstruction based on event timing in spreading processes — Forough Hassanibesheli[1,2] and •Reik V. Donner[1,3] — [1]PIK Potsdam, Germany — [2]Humboldt University, Potsdam, Germany — [3]Magdeburg-Stendal University of Applied Sciences, Magdeburg, Germany

Spreading phenomena like opinion formation or disease propagation commonly follow the links of some underlying network structure. While the effect of network topology on spreading efficiency has already been vastly studied, we here address the inverse problem whether we can infer an unknown network structure from the timing of events at different nodes. For this purpose, we consider a simple model of nodes exhibiting two types of activity: spontaneous events that are generated via mutually independent Poisson processes, and triggered events that occur with a certain probability whenever one of the neighboring nodes exhibits any of these two kinds of events. Based on simulations of this model for different types of networks, we study the similarity between the timings of events at all pairs of nodes by means of event synchronization and event coincidence analysis as two wide-spread methods for studying simultaneity in event series. By taking strong mutual similarities as proxies for actual physical links, we demonstrate that both approaches lead to similar prediction accuracy. In general, sparser networks can be reconstructed more accurately than denser ones, especially in case of larger networks.

SOE 12.13 Tue 16:00 Poster A

Interplay of adaptivity and multiplexing in networks of coupled oscillators — Rico Berner[1,2], •Jakub Sawicki[1], Anna Zakharova[1], and Eckehard Schöll[1] — [1]Institute of Theoretical Physics, Technische Universität Berlin, Germany — [2]Institute of Mathematics, Technische Universität Berlin, Germany

Research on multilayer networks has recently opened up new aspects, providing a description of systems interconnected through different types of links. One class of interactions are within the layers, and additionally other types of interactions occur between the network nodes from different layers. In addition, dynamical systems on networks with time dependent topology have attracted a lot of attention in studies of neural networks, power grids as well as social groups. We study the

impact of multiplexing on the collective dynamics in adaptive layers. Building on these investigations the analysis of self-organized emergent symmetric networks is lifted to multiplex structures. We show that multiplex networks give rise to promising new control schemes.

SOE 12.14 Tue 16:00 Poster A

Noise-induced chimeras in dynamical networks: nonlocally coupled ring versus 2D modular fractal connectivity — •Anna Zakharova, Nikolas Heym, and Eckehard Schöll — Technische Universität Berlin

For a network of coupled neural elements in the excitable regime we show that chimera patterns can be induced by noise. We compare the results for two different network topologies: nonlocal coupling on a ring and 2D modular fractal connectivity, with the latter being relevant for modeling of the brain. In contrast to classical chimeras, occurring in noise-free oscillatory networks, these patterns have features of two phenomena: coherence resonance and chimera states. Therefore, we call them coherence-resonance chimeras [1]. They demonstrate the constructive role of noise and appear for intermediate values of noise intensity. We investigate the impact of time delay on coherence-resonance chimeras and show that time-delayed feedback can be used to control the noise-induced chimera states [2].

[1] N. Semenova, A. Zakharova, V. Anishchenko, E. Schöll, Coherence-resonance chimeras in a network of excitable elements, Phys. Rev. Lett. 117, 014102 (2016)

[2] A. Zakharova, N. Semenova, V. Anishchenko, E. Schöll, Time-delayed feedback control of coherence resonance chimeras, Chaos 27, 114320 (2017)

SOE 12.15 Tue 16:00 Poster A

Weak multiplexing in neural networks: Switching between chimera and solitary states — •Anna Zakharova[1], Maria Mikhaylenko[1,2], Lukas Ramlow[2], and Sarika Jalan[3] — [1]Technische Universität Berlin, Germany — [2]ITMO University, St.Petersburg, Russia — [3]IIT Indore, India

Using the model of a FitzHugh-Nagumo system in the oscillatory regime, we study spatio-temporal patterns occurring in a two-layer multiplex network, where each layer is represented by a non-locally coupled ring [1]. We show that weak multiplexing, i.e., when the coupling between the layers is smaller than that within the layers, can have a significant impact on the dynamics of the neural network. We develop control strategies based on weak multiplexing and demonstrate how the desired state in one layer can be achieved without manipulating its parameters, but only by adjusting the other layer. We find that weak multiplexing allows to induce or suppress chimera states. Interestingly, for small intra-layer coupling strength mismatch, solitary states can be induced throughout the whole network.

[1] M. Mikhailenko, L. Ramlow, S. Jalan and A. Zakharova, Weak multiplexing in neural networks: Switching between chimera and solitary states, arXiv:1809.07148 (2018)

SOE 12.16 Tue 16:00 Poster A

Partial synchronization in 2-community networks of FitzHugh-Nagumo oscillators with empirical structural connectivities — Lukas Ramlow, •Jakub Sawicki, and Eckehard Schöll — Institute of Theoretical Physics, Technische Universität Berlin, Germany

Partial synchronization includes patterns of coexistence of a synchronized and desynchronized subgroup of oscillators. A real world phenomenon where this can be found is uni-hemispheric slow-wave sleep where one hemisphere is asleep while the other remains awake. This state can also be characterized by simultaneous but spatially separated occurrence of high and low degree of synchronization in the sleeping and the awake hemisphere, respectively. Here we investigate the occurrence of partial synchronization patterns in empirical structural connectivities of the human brain. The connectivities consist of ninety regions of interest using the Automated Anatomical Labeling (AAL) Atlas, and were derived by magnetic resonance imaging (MRI) based probabilistic diffusion tractography. The local dynamics is modeled by FitzHugh-Nagumo oscillators. We demonstrate under which conditions partial synchronization patterns with respect to the brain hemispheres can be found.

SOE 12.17 Tue 16:00 Poster A

Synchronization of chimera states in multiplex networks of logistic maps — Marius Winkler, •Jakub Sawicki, Iryna Omelchenko, Anna Zakharova, and Eckehard Schöll — Institute of Theoretical Physics, Technische Universität Berlin, Germany

Complex networks consisting of several interacting layers allow for remote synchronization of distant layers via an intermediate relay layer. We extend the notion of relay synchronization to chimera states, and study the scenarios of relay synchronization in a three-layer network of logistic maps, where each layer has a nonlocal coupling topology. Varying the coupling strength in the inter-and intra-layer connections, we observe various complex spatio-temporal patterns of coexisting coherent and incoherent domains, i.e., chimera states, in the outer network layers. Special regimes where only the coherent domains of chimeras are synchronized, and the incoherent domains remain desynchronized, as well as transitions between different synchronization regimes are analyzed.

SOE 13: Dynamics of Multilayer Networks I (Focus Session SOE/DY/BP) (joint session SOE/DY/BP)

Recently, multilayer networks have been suggested to offer a better representation of the topology and dynamics of real-world systems in comparison with isolated one-layer structures. The prime objective of multiplex networks is to explore multiple levels of interactions where functions of one layer get affected by the properties of other layers. One of the most promising applications of the multilayer approach is the study of the brain, or technological interdependent systems, i.e., those systems in which the correct functioning of one of them strongly depends on the status of the others. The purpose of this focus session is to bring together researchers working on multilayer networks and to share recent ideas and results in the field. (The sessions Dynamics of Multilayer Networks I + II have been organized by Anna Zakharova and Sarika Jalan.)

Time: Wednesday 9:30–12:00 Location: H17

Topical Talk SOE 13.1 Wed 9:30 H17

Inhibition induced explosive synchronization in multiplex network — •Sarika Jalan — Complex Systems Lab, IIT Indore, Indore 453552

To date, explosive synchronization (ES) is shown to be originated from either degree-frequency correlation or inertia of phase oscillators. Of late, it has been shown that ES can be induced in a network by adaptively controlled phase oscillators. We show that ES can occur in any network by appropriately multiplexing it with another layer. We devise an approach which leads to the occurrence of ES with hysteresis loop in a network upon its multiplexing with a negatively coupled (or inhibitory) layer. We discuss the impact of various structural properties of positively coupled (or excitatory) and inhibitory layer along with the strength of multiplexing in gaining control over the induced ES transition. This investigation is a step forward in highlighting the importance of multiplex framework not only in bringing novel phenomena which are not possible in an isolated network but also in providing more structural control over the induced phenomena.

Topical Talk SOE 13.2 Wed 10:00 H17

Percolation on multi-layer networks — •Filippo Radicchi — Indiana University, Bloomington, Indiana, United States

In this talk, I will review some of my recent papers about percolation on multi-layer networks. I will first illustrate a theoretical approach consisting in a system of heuristic equations able to approximate the phase diagram of the ordinary percolation model for arbitrary multi-layer networks. Second, I will introduce and characterize the redundant percolation model, a genuine model for multi-layer networks where the addition of new layers boosts system robustness by creating redundant interdependencies among layers. Third, I will generalize the problem of optimal percolation from single-layer to multi-layer networks, and present several algorithms for finding approximate solutions to the problem. Finally, I will present a large-deviation approach to ordinary percolation able to shed light on the importance of fluctuations in the study of percolation on real-world multi-layer networks.

15 min. break

Topical Talk SOE 13.3 Wed 10:45 H17

Mean field phase synchronization across multilayer networks in chimera states — •Ralph Gregor Andrzejak[1], Giulia Ruzzene[1], Kaspar Schindler[2], Eckehard Schöll[3], and Anna Zakharova[3] — [1]Dept. of Information and Communication Technologies, Univ. Pompeu Fabra, Barcelona, Spain — [2]Dept. of Neurology, Sleep-Wake-Epilepsy-Center, Inselspital, Univ. Bern, Switzerland — [3]Inst. für Theoretische Physik, Technische Univ. Berlin, Germany

Chimera states are an intriguing interplay of synchronous and asynchronous motion in networks of coupled oscillators. While chimera states were traditionally studied in one-layer networks, recent work studies interactions of chimera states across coupled layers in multi-layer networks. We here review our recent work in which we applied different types of couplings between pairs of networks that individually show chimera states when there is no coupling between them. We show that these couplings across network layers can lead to generalized synchronization [1] and phase synchronization [2] between networks, while both layers continue to exhibit distinct chimera states. We show that these synchronization phenomena are in close analogy to those found for low-dimensional chaotic dynamics.

References: [1] Andrzejak, R. G., Ruzzene, G., & Malvestio, I. (2017). Generalized synchronization between chimera states. Chaos, 27(5), 053114.

[2] Andrzejak, R. G., Ruzzene, G., Malvestio, I., Schindler, K., Schöll, E., & Zakharova, A. (2018). Mean field phase synchronization between chimera states. Chaos, 28(9), 091101.

SOE 13.4 Wed 11:15 H17

Weak multiplexing induces coherence resonance — •Nadezhda Semenova[1,2] and Anna Zakharova[3] — [1]Department of Physics, Saratov State University, Saratov, Russia — [2]FEMTO-ST / Optics Dept., Univ. Bourgogne Franche-Comté, Besançon Cedex, France — [3]Institut für Theoretische Physik, Technische Universität Berlin, Berlin, Germany

Using the model of a FitzHugh-Nagumo system in the excitable regime, we study the impact of multiplexing on coherence resonance in a two-layer network [1]. We show that multiplexing allows for the control of the noise-induced dynamics. In particular, we find that multiplexing induces coherence resonance in networks that do not demonstrate this phenomenon in isolation. Examples are provided by deterministic networks and networks where the strength of interaction between the elements is not optimal for coherence resonance. In both cases, we show that the control strategy based on multiplexing can be successfully applied even for weak coupling between the layers. Moreover, for the case of deterministic networks, we obtain a counter-intuitive result: the multiplex-induced coherence resonance in the layer which is deterministic in isolation manifests itself even more strongly than that in the noisy layer.

[1] N. Semenova, A. Zakharova, Weak multiplexing induces coherence resonance, Chaos 28, 051104 (2018)

Topical Talk SOE 13.5 Wed 11:30 H17

Relay synchronization in multiplex networks — •Inmaculada Leyva[1,2], Irene Sendina-Nadal[1,2], Ricardo Sevilla-Escoboza[3], and Victor Vera-Avila[3] — [1]Complex Systems Group & GISC, Universidad Rey Juan Carlos, Madrid, Spain — [2]Center for Biomedical Technology, Universidad Politécnica de Madrid, Madrid, Spain — [3]Centro Univ. de los Lagos, Universidad de Guadalajara, Jalisco, Mexico

The relay synchronization is observed when two dynamical units synchronize despite not being directly linked, due to the intermediation of a relay mismatched unit. In our work we have extended the concept of relay synchronization to the case of a multiplex network, showing that the intermediation of a relay layer can lead to inter-layer synchronization of a set of paired layers, both topologically and dynamically different from the transmitter. The phenomenon can be extended to indefinitely higher order relay configurations, provided a mirror symmetry is preserved in the multiplex. The coherent state is very robust to changes in the dynamics, topology, and even to strong multiplex disconnection.Our results provide a new path for starting the study of the role of symmetries in setting long distance coherence in real systems, specially in brain networks, where remote synchronization is of outstanding relevance for coordination between remote cortical areas.

SOE 14: Annual Member's Assembly

Agenda: 1. Report on activities and Announcements. 2. Miscellaneous and Disusssion. 3. Elections.

Time: Wednesday 12:00–13:00 Location: H17

Annual assembly of members of SOE (all interested participants are welcome to join).

SOE 15: Dynamics of Multilayer Networks II (Focus Session SOE/DY/BP) (joint session SOE/DY/BP)

Time: Wednesday 15:00–16:45 Location: H17

Topical Talk SOE 15.1 Wed 15:00 H17

Delay controls chimera relay synchronization in multiplex networks — •Eckehard Schöll, Jakub Sawicki, Iryna Omelchenko, and Anna Zakharova — Institut für Theoretische Physik, Technische Universität Berlin, Germany

We study remote (or relay) synchronization in multilayer networks between parts of one layer and their counterparts in a second layer, where these two layers are not directly connected. A simple realization of such a system is a triplex network where a relay layer in the middle, which is generally not synchronized, acts as a transmitter between two outer layers; an example is provided by the hippocampus connecting distant parts of the brain. We find various partial synchronization patterns, in particular chimera states, i.e., complex patterns of coexisting coherent and incoherent domains, and establish time delay in the inter-layer coupling as a powerful tool of control [1]. We demonstrate that the three-layer structure of the network allows for synchronization of the coherent domains of chimera states in the first layer with their counterparts in the third layer, whereas the incoherent domains either remain desynchronized or synchronized. As model dynamics we use the paradigmatic FitzHugh-Nagumo system.

[1] J. Sawicki, I. Omelchenko, A. Zakharova, and E. Schöll, arXiv:1807.11223v2 (2018).

SOE 15.2 Wed 15:30 H17

Spiral wave patterns and their synchronization in lattices of nonlocally coupled discrete-time systems — Andrei Bukh, Galina Strelkova, and •Vadim Anishchenko — Saratov State University, Saratov, Russia

We investigate numerically the spatio-temporal dynamics of a 2D lattice of coupled discrete-time systems with nonlocal interaction. The individual map is given by a universal discrete system (the Nekorkin map) proposed for modeling the neural activity. The network behavior is studied for periodic and open boundary conditions. It is shown that for certain values of the nonlinear coupling parameters, rotating spiral waves and spiral wave chimeras can be observed in the considered lattice. We analyze and compare statistical and dynamical characteristics of the local oscillators from coherence and incoherence clusters of a spiral wave chimera. We also explore the effects of partial and complete synchronization of spiral wave chimeras in two coupled lattices of discrete maps with varying the intercoupling between the networks.

SOE 15.3 Wed 15:45 H17

Synchronization of spiral wave patterns in coupled 2D lattices of discrete maps — •Andrei Bukh[1], Eckehard Schöll[2], and Vadim Anishchenko[1] — [1]Saratov State University, Saratov, Russia — [2]Technical University, Berlin, Germany

We study numerically the dynamics of two symmetrically and unidirectionally coupled lattices of nonlocally coupled two-dimensional Nekorkin maps. The phenomena of external and mutual synchronization of spiral wave patterns including chimera states are explored. The partial and complete synchronization is analyzed by calculating the number of synchronous elements in the coupled lattices depending on the coupling strength between them. Synchronous regimes are quanitified by using mutual correlation coefficients between the relevant elements in the lattices.

SOE 15.4 Wed 16:00 H17

Transmission and synchronization of chimeras in a multilayer network of nonlocally coupled chaotic maps — •Galina Strelkova and Tatiana Vadivasova — Saratov State University, Saratov, Russia

We explore numerically transmission and external synchronization of chimera states in a multilayer network of unidirectionally coupled rings of nonlocally coupled logistic maps. We consider two cases: when all M coupled layers are identical (homogeneous) and when (M-1) identical layers differ from the first driving layer in their nonlocal coupling parameters. It is shown that the master chimera state in the first layer can be retranslating along the network with small distortions which are defined by a parameter mismatch. The synchronization effect is evaluated by calculating the mean-square deviation of the structure in the layers when varying the nonlocal coupling parameters.

SOE 15.5 Wed 16:15 H17

Synchronization of chimera states in multilayer heterogeneous network of nonlocally coupled maps — •Elena Rybalova[1], Galina Strelkova[1], Tatiana Vadivasova[1], and Anna Zakharova[2] — [1]Saratov State University, Saratov, Russia — [2]Technical University, Berlin, Germany

We present numerical results on the study of a complex network composed of many asymmetrically coupled heterogeneous layers of nonlocally coupled logistic maps. Transmission and synchronization of chimera states realized in the first (master) layer is considered for mutual and unidirectional inter-coupling between the layers. It is shown that there is a threshold of the forced synchronization, which is different for various chimeras (phase and amplitude) in the master layer. It is established that the presence of feedback (backward) inter-coupling is a significant obstacle for global synchronization across the network. We also analyze and compare the role of heterogeneity in control and coupling parameters on the degree of forced synchronization.

15 min. break

SOE 16: Networks and Systemic Risks (joint SOE/DY)

Time: Thursday 9:30–11:30 Location: H17

SOE 16.1 Thu 9:30 H17

Large-deviation properties of random graphs — •Alexander K. Hartmann — University of Oldenburg

Distributions of the size of the largest component of the 2-core and of the graph diamater for Erdős-Rényi (ER) random graphs with finite connectivity c and a finite number N of nodes are numerically studied [1]. The distributions are obtained basically over the full range of the support, with probabilities down to values as small as 10^{-320}. This is achieved by using an artificial finite-temperature (Boltzmann) ensemble. The distributions for the 2-core [2] resemble roughly the results obtained previously [3] for the largest components of the full ER random graphs, but they are shifted to much smaller probabilities ($c \leq 1$) or to smaller sizes ($c > 1$). For the diameter [4], for values $c < 1$, our results are in good agreement with analytical results. For $c > 1$ the distribution is more complex and no complete analytical results are available.

For both cases, the numerical data is compatible with a convergence of the rate function to a limiting shape, i.e., the large-deviations principle apparently holds.

[1] A. K. Hartmann, Big Practical Guide to Computer Simulations, World-Scientific, Singapore (2015)
[1] A.K. Hartmann, Eur. Phys. J. Special Topics **226**, 567 (2017)
[2] A.K. Hartmann, Eur. Phys. J. B **84**, 627-634 (2011)
[3] A.K. Hartmann and M. Mézard, Phys. Rev. E **97**, 032128 (2018)

SOE 16.2 Thu 10:00 H17

Sparse Network Reconstruction and Systemic Risk — •Alexander Becker[1], Irena Vodenska[1], and Diego Garlaschelli[2] — [1]Boston University, Boston, USA — [2]IMT Lucca, Lucca, Italy

The study of systemic risk in complex networks requires both a good model and detailed knowledge of the network. Often, we cannot observe individual edges, and information is only available about the nodes on an aggregate level. If systemic risk is to be modeled as a shock propagation, an accurate estimate of the edges is imperative. Recently, a variety of network reconstruction methods has been put forth, of which the configuration model based on the principle of maximum entropy has emerged as a front runner.

Remarkably, such reconstruction attempts on the Japanese firm-bank data set have yielded networks which underestimate the systemic risk in the system. We establish limits on the applicability of reconstruction methods for sparse networks and demonstrate the implications for systemic risk analysis.

SOE 16.3 Thu 10:15 H17

Agent Bases Models and Complex Networks for Insurance Riskmanagement — •Magda Schiegl — University of Applied Sciences, Landshut, Germany

Riskmanagement is a main topic in insurance business with a variety of methods that are used traditionally in this field. The natural sciences develop models and methods to describe and understand complex systems. Some of the most successful developments of the last few decades are agent based models and complex networks. They have also been applied to socio-economic contexts and have been documented in a huge amount of scientific literature. We deal with the application of agent based models and complex networks in insurance business. We give a review of scientific research in these fields with special relevance for riskmanagement. Some examples that can be examined and/or modelled with this kind of methods are: risk aggregation schemes as the Solvency II tree structure in the context of networks, credit risk, pandemia, supply chain and operational risk. Further we focus on one of the few published agent based models for a typical insurance application. It is embedded in an economic context and published in an actuarial journal. We formulate it as a discrete time dynamic model and discuss it from the physic*s point of view. We compare our results with Monte Carlo simulations of the model.

SOE 16.4 Thu 10:30 H17

Reproducibility in Statistical Analysis of Natural Language: the case of Project Gutenberg — •Francesc Font-Clos[1] and Martin Gerlach[2] — [1]Center for Complexity and Biosystems, University of Milan, Italy — [2]Department of Chemical and Biological Engineering, Northwestern University, USA

Data from the Project Gutenberg (PG) has been extremely popular in statistical analysis of language for more than 25 years. However,

in contrast to other fields, no standardized consensual version of the dataset exists to date. In fact, most PG studies so far either consider only a small number of manually selected books, leading to potentially biased subsets, or employ vastly different pre-processing strategies (often specified in insufficient details).

In order to address these shortcomings, we present the Standardized Project Gutenberg Corpus (SPGC), an open science approach to a curated version of the complete PG data containing more than 50,000 books and more than 3×10^9 word-tokens. We publish our methodology in detail, the code to download and process the data, as well as the corpus itself on 3 different levels of granularity. In this way, we provide a reproducible, pre-processed, full-size version of Project Gutenberg as a new scientific resource for corpus linguistics, natural language processing, and information retrieval.

Manuscript: arxiv.org/abs/1812.08092

Code: github.com/pgcorpus/gutenberg

Data: zenodo.org/record/2422561

SOE 16.5 Thu 10:45 H17

Failure and reliability in gene regulatory networks — •Stefan Bornholdt — Universität Bremen, Germany

Life is based on reliable regulation and control of cells and multicellular organisms. Complex networks of interacting genes and proteins perform this task with great precision, despite being implemented in "wetware" with huge biochemical stochasticity. This implies risk of network failure in every single moment. I here review biological strategies to tackle these uncertainties and secure reliable performance in regulatory networks. The astonishingly reliable cell cycle control network in Yeast, central to beer production, will be used to exemplify control mechanisms in detail.

15 min. break

SOE 17: The Physics of Power grids (joint session DY/SOE)

Time: Thursday 10:30–11:15 Location: H6

SOE 17.1 Thu 10:30 H6

Comparison of coupled nonlinear oscillator models for the transient response of power generating stations connected to low inertia systems — Marios Zarifakis[1], William Coffey[2], Yuri Kalmykov[3], Serguey Titov[4], •Declan Byrne[2], and William Dowling[2] — [1]Electricity Supply Board, Dublin, Ireland — [2]Department of Electronic and Electrical Engineering, Trinity College, Dublin 2, Ireland — [3]Laboratoire de Mathematiques et Physique (EA 4217), Universite de Perpignan Via Domitia, F-66860, Perpignan, France — [4]Kotel'nikov Institute of Radio Engineering and Electronics of the Russian Academy of Sciences, Vvedenskii Square 1, Fryazino, Moscow Region 141120, Russia

Coupled nonlinear oscillators, e.g., Kuramoto models, are commonly used to analyze electrical power systems. Recently the cage model from the statistical mechanics of liquids has also been used for the modelling of the dynamics of synchronously connected generation stations. It appears that while the Kuramoto model is good for describing high inertia grid systems, the cage model allows both high and low inertia grids to be modelled. This is demonstrated by comparing both the synchronization time and relaxation towards synchronization of each model of power generating stations by treating the model equations of motion via a common framework rooted in the dynamics of many coupled phase oscillators. A solution of these equations via matrix continued fractions is implemented rendering the characteristic relaxation times of a grid-generator system over a wide range of inertia and damping.

SOE 17.2 Thu 10:45 H6

Enhancing power grid synchronization and stability through time delayed feedback control — •Halgurd Taher[1,2], Simona Olmi[2,3], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, Technische Universität Berlin, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Inria Sophia Antipolis Méditerranée Research Centre, 2004 Route des Lucioles, 06902 Valbonne, France — [3]CNR - Consiglio Nazionale delle Ricerche - Istituto dei Sistemi Complessi, 50019, Sesto Fiorentino, Italy

The increasing inclusion of renewable energy sources into the power grid brings new challenges for its stable operation, due to the presence of various forms of perturbations which may possibly harm stability and synchronization. In this talk asynchrony of single nodes in power grids is investigated using real data of the sparsely connected German high-voltage transmission grid. Based on time-delayed feedback control, diffferent control strategies are proposed and compared. The strategies not only take into account solitary states, but also the Lyapunov vector corresponding to the largest (positive) Lyapunov exponent. Starting from an unstable state out of synchrony, we are able to frequency-synchronize and stabilize power grids by just controlling a small set of nodes. The numerical calculation of the Lyapunov spectrum allows us to explore the mechanism behind the control-induced resynchronization transition.

SOE 17.3 Thu 11:00 H6

Control of synchronization in two-layer power grids — •Carl H. Totz[1], Simona Olmi[2], and Eckehard Schöll[1] — [1]Institut für Theoretische Physik, TU Berlin, Hardenbergstr. 36, D-10623 Berlin — [2]INRIA Sophia Antipolis Méditerranée, 2004 Route des Lucioles, 06902 Valbonne, France

The dynamics of a two-layer network modeling the Italian high voltage power grid is investigated: the first layer represents the generators and consumers, while the second layer represents a dynamic communication network between generators that serves as controller of the first layer. The dynamics of the power grid is modeled by the Kuramoto model with inertia, while the second layer provides a control signal P_i^c for each generator to improve frequency synchronization within the power grid.

We investigate different realizations of the communication layer topology and different control methods. The two-layer system is tested for different perturbation scenarios (disconnecting some generators, increasing demand of consumers, generators with stochastic output) and, irrespectively of the applied perturbation, we find that the control scheme aimed to synchronize the frequency of the generators with the consumers is very efficient against almost all perturbation scenarios.

SOE 18: Energy Networks (joint SOE/DY) (joint session SOE/DY)

Time: Thursday 11:30–12:30 Location: H17

SOE 18.1 Thu 11:30 H17

Principal flow patterns across renewable electricity networks — •Mirko Schäfer[1], Fabian Hofmann[2], Johannes Kruse[3], Tom Brown[4,2], Jonas Hörsch[4,2], Stefan Schramm[2], and Martin Greiner[3] — [1]Department of Sustainable Systems Engineering (INATECH), Albert-Ludwigs-Universität Freiburg — [2]Frankfurt Institute for Advanced Studies — [3]Department of Engineering, Aarhus University, Denmark — [4]Institute for Automation and Applied Informatics, Karlsruhe Institute of Technology

Using Principal Component Analysis (PCA), the nodal injection and line flow patterns in a network model of a future highly renewable European electricity system are investigated. Remarkably, the application of PCA to the transmission line power flow statistics shows that irrespectively of the spatial scale of the system representation a very low number of only 8 principal flow patterns is sufficient to capture 95% of the corresponding spatio-temporal variance. This result can be theoretically explained by a particular alignment of some principal injection patterns with topological patterns inherent to the network structure of the European transmission system. By connecting these insights to a spectral clustering method it is shown how through topological changes the flow patterns on the network can be controlled.

SOE 18.2 Thu 11:45 H17

Flow Redistribution after Link Failures in Linear Flow Networks — •Franz Kaiser[1,2], Julius Strake[1,2], Henrik Ronellenfitsch[3], and Dirk Witthaut[1,2] — [1]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE) — [2]University of Cologne, Institute for Theoretical Physics — [3]Department of Mathematics, Massachusetts Institute of Technology

Failing links can degrade the operation of a supply network up to the point of complete collapse. Yet, the interplay between network topology and locality of the response to such damage is poorly understood. Here, we study the role of topology for the redistribution of flow after the failure of links in linear flow networks with a special focus on power grids. In particular, we analyze the decay of flow changes with distance after a link failure and examine the interplay of multiple lines failing at the same time. In addition to that, we introduce a rerouting distance to predict this decay for real-world networks and use this tool for describing the interaction of multiple outages. Our results show that it is possible to forecast flow rerouting after link failures to a large extent based on purely topological measures and that these effects generally decay with distance from the failing link.

SOE 18.3 Thu 12:00 H17

Understanding power-grid-frequency dynamics with stochastic modelling: The influence of the electricity market — •Leonardo Rydin Gorjão[1,2], Mehrnaz Anvari[3], Holger Kantz[3], Marc Timme[4,5], Benjamin Schäfer[4,5], and Dirk Witthaut[1,2] — [1]Forschungszentrum Jülich, Institute for Energy and Climate Research - Systems Analysis and Technology Evaluation (IEK-STE), 52428 Jülich, Germany — [2]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany — [3]Max–Planck Institute for the Physics of Complex Systems, 01187 Dresden, Germany — [4]Chair for Network Dynamics, Center for Advancing Electronics Dresden (cfaed) and Institute for Theoretical Physics, Technical University of Dresden, 01062 Dresden, Germany — [5]Network Dynamics, Max Planck Institute for Dynamics and Self-Organization (MPIDS), 37077 Göttingen, Germany

The ongoing energy transition transforms the power system by introducing additional fluctuations via intermittent renewable energy generation To evaluate the various proposed strategies of implementation of renewable energy generation and the impact of market design on the power grid's stability, a solid understanding of the power grid dynamics, specifically its frequency, is necessary. A pure empirical study on existing power grids is limited due to their small number, limited available data and high costs of implementing control and market schemes in real grids. Our model allows predictions of the frequency statistics for diverse power grids and ultimately enables us to quantify the impact of control proposals and market designs.

SOE 18.4 Thu 12:15 H17

Effects of time delay on the control of synchronous electricity grids — •Philipp C. Böttcher[1], Andreas Otto[2], and Stefan Kettemann[3] — [1]DLR-Institut für Vernetzte Energiesysteme, Oldenburg — [2]Institute of Physics, TU Chemnitz, Chemnitz — [3]Department of Physics and Earth Sciences, Jacobs University, Bremen

In the course of the 'Energiewende', highly volatile energy sources (i.e. wind and photovoltaics) will be introduced to a system built with conventional energy sources in mind. Removing conventional energy sources and replacing them with fluctuating renewable generation that does not provide inertia could make the system vulnerable to disturbances. Control mechanisms can only be employed by accurately measuring the system state (i.e. frequencies and load flows) and correctly communicating theses values. The delay associated with the measurement, communication and deployment of control might play an increasingly important role in a system that relies on strongly fluctuating feed-in.
The control mechanisms used at the moment are integrated into a model of coupled oscillators which resembles the second order Kuramoto model. This model is used to investigate the behavior of the interconnected electricity grid. To identify regions in parameter space that make stable grid operation possible, the linearized system is analyzed to create the system's stability chart. The influence of the control parameters, the underlying network topology and the delay on the grid frequency is of special interest.

SOE 19: Focus Session: Theory of Stochastic Processes with Applications in Biology (joint session SOE/BP/DY/AKjDPG)

Session initiated and organized by Rosalba Garcia Millan, Johannes Pausch and Ignacio Bordeu Weldt (Imperial College, UK), in cooperation with divisions DY, BP, SOE and the jDPG.

Time: Thursday 15:00–18:45 Location: H17

Invited Talk SOE 19.1 Thu 15:00 H17

Ecosystem stability and altruistic advantage — •Nick Jones — Imperial College Mathematics, London, UK

In this talk I consider why many, empirically observed, directed networks might contain a lack of feedback loops. An answer might be network growth mechanisms that favour clear trophic levels and which generate assymetries between the in degrees and out degrees of nodes. This is a partial answer to May's (Complexity-Stability) Paradox. Finally I will outline an, ageing relevant, concrete biological example of spatial demographic stochasticity where altruists can dominate a system even when actively selected against.

SOE 19.2 Thu 15:45 H17

Thermodynamics of steady-state switching — •Jacob Cook[1,2] and Robert G. Endres[1,2] — [1]Department of Life Sciences, Imperial College, London, UK — [2]Centre for Integrative Systems Biology and Bioinformatics, Imperial College, London, UK

Entropy production is a hallmark of nonequilibrium processes in stochastic thermodynamics. Multistable nonequilibrium systems are abundant outcomes of nonlinear dynamics with feedback yet relatively little is known about what determines the stability of the steady states and their switching rates in terms of entropy and entropy production. Here, we will link the fluctuation theorem for the entropy produc-

tion along trajectories and the large-deviation approach of minimum-action-path theory to elucidate the thermodynamics of steady-state switching. Interestingly, we find that the entropy production at steady state plays no explicit role, but the entropy production along switching trajectories is key. Alternative stabilising and destabilising mechanisms such as steady-state entropy and diffusive noise are also investigated.

SOE 19.3 Thu 16:00 H17

Dynamical phase transition in assemblies of chemotactic cells — •Charlie Duclut — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

We consider a large number of chemotactic cells that diffuse, die, divide and interact at long range via the release of chemicals. We investigate the dynamics at long time and focus on the phase transition that occurs between a dilute and a dense phase using a renormalization group analysis. If we consider only interactions that conserve the particles number, exact scaling exponents can even be obtained; this analysis predicts in particular a superdiffusive behaviour of the cells close to the phase transition.

Invited Talk SOE 19.4 Thu 16:15 H17

Topological Hindrance and Jamming Transitions in Multi-Species Transport — •Erwin Frey — Arnold-Sommerfeld-Center for Theoretical Physics, Ludwig-Maximilians-Universität München, München, Germany

Motivated by recent experimental studies that have addressed the stepping behavior of kinesins, we investigate a lattice gas model for simultaneous transport of two species of active particles on a microtubule. The species are distinguished by their different gaits: While the first species moves straight ahead, the second follows a helical path. We show that the collective properties of such systems critically differ from those of one-species transport as described by generalised totally asymmetric exclusion processes. This is most evident in a jamming transition far below full occupation, as well as in nonequilibrium pattern formation. The altered behavior arises because - unlike the case in single-species transport - any given position may be targeted by two particles from different directions at the same time. However, a particle can leave a given position only in one direction. This simple change in connectivity significantly amplifies the impact of steric interactions and thus becomes a key determinant of mixed species transport. We computationally characterize this type of hindrance and develop a comprehensive stochastic theory for collective two-species transport along a cylinder. Our observations show high robustness against model extensions that account for additional biomolecular features which suggests relevance also in a biological context.

15 min. break

Invited Talk SOE 19.5 Thu 17:00 H17

Seeing and believing at super-resolution — •Susan Cox — Randall Centre for Cell and Molecular Biophysics, King's College London

Super-resolution microscopy is a powerful tool for imaging structures at a lengthscale of tens of nm, but its utility for live cell imaging is limited by the time it takes to acquire the data needed for an image. For localisation microscopy the acquisition time can be cut by more than two orders of magnitude by using advanced algorithms which can analyse dense data, trading off acquisition and processing time. Information can be traded for resolution: for example, the whole dataset can by modelled as arising from blinking and bleaching fluorophores (Bayesian analysis of Blinking and Bleaching), although at a high computational cost. However, all these approaches will come with a risk of artefacts, which can mean that the image does not resemble the underlying sample. We have recently developed Harr Wavelet Kernel Analysis, a multi-timescale prefiltering technique which enables high density imaging without artefacts. The results of benchmarking with other techniques reveal that at high activation densities many analysis approaches may achieve high apparent precision (very sharp images), but poor accuracy (the images don't look like the sample). I will discuss the relationship between precision, accuracy and information content in super-resolution microscopy images.

SOE 19.6 Thu 17:45 H17

Filament flexibility enhances power transduction of F-actin bundles — •Alessia Perilli[1], Carlo Pierleoni[2], Giovanni Ciccotti[1], and Jena-Paul Ryckaert[3] — [1]Dept. of Physics, Sapienza University of Rome, Italy — [2]Dept. of Physical and Chemical Sciences, University of L'Aquila, Italy — [3]Dept. of Physics, Free University of Brussels, Belgium

In different biophysical cellular processes, semiflexible biofilaments like Factin and F-tubulin are known to exploit chemical free energy, associated to their growth by polymerization, to perform mechanical work against an external load. In vitro experiments have recently been set up to measure the force-velocity relationship of an actin bundle or to equilibrate the bundle polymerizing force by an optical trap restoring force. Theoretical interpretation is usually based on multi filament brownian ratchet models assuming perfectly rigid filaments (Mogilner-Oster). In this talk, we will exploit statistical mechanics tools and a coarse grained stochastic dynamic approach based on the discrete Wormlike Chain (WLC) model, to study the influence of filament flexibility on the non-equilibrium velocity-load relationship for a bundle of parallel un-crosslinked actin filaments pressing against a mobile wall. Using a realistic value of the actin persistence length, we show that flexibility enhances the power developed by the polymerizing force against the load in a way which increases with the length of the bundle, as long as the pushing filaments remain in the nonescaping regime.

Topical Talk SOE 19.7 Thu 18:00 H17

Reconstructing the topographic landscape of epithelial-mesenchymal plasticity — •Francesc Font-Clos, Stefano Zapperi, and Caterina A. M. La Porta — Center for Complexity and Biosystems, University of Milan, Italy

We construct a topographic map underlying epithelial-mesenchymal plasticity by combining numerical simulations, statistical physics methods and analysis of bulk and single-cell gene expression data. The map reveals a multitude of metastable hybrid phenotypic states, separating stable epithelial and mesenchymal states, and is reminiscent of the free energy measured in glassy materials and disordered solids.

Topography of epithelial-mesenchymal plasticity, Francesc Font-Clos, Stefano Zapperi, Caterina A. M. La Porta, Proceedings of the National Academy of Sciences Jun 2018, 115 (23) 5902-5907; DOI: 10.1073/pnas.1722609115

SOE 19.8 Thu 18:30 H17

Beating cancer 'escape room': let's use mathematical modelling to unlock cells! — •Núria Folguera-Blasco — The Francis Crick Institute, London, UK

The inherent capacity of differentiated cells to switch their phenotype in vivo in response to damage stimuli might have a pivotal role in ageing and cancer. However, how the mechanisms of phenotype reprogramming are established remains poorly understood. In order to elucidate such mechanisms, we present a stochastic model of combined epigenetic regulation (ER)-gene regulatory network (GRN) to study the plastic phenotypic behaviours driven by ER heterogeneity. Our analysis of the coupled system reveals the existence of pluripotent stem-like and differentiated steady-states. Crucially, ER heterogeneity is responsible for conferring abnormal robustness to pluripotent stem-like states, which cause the locking of the cells in a stem cell-like state prone to cancer development. By analysing the ER heterogeneity, we formulate epigenetic heterogeneity-based strategies capable of unlocking and facilitating the transit from differentiation-refractory (pluripotent stem-like) to differentiation-primed epistates. Our results suggest that epigenetic heterogeneity regulates the mechanisms and kinetics of phenotypic robustness of cell fate reprogramming. The occurrence of tunable switches capable of modifying the nature of cell fate reprogramming from pathological to physiological might pave the way for new therapeutic strategies to regulate reparative reprogramming in ageing and cancer.