SOE 6: Poster

Time: Monday 17:00–20:00 Location: P2/4OG

SOE 6.1 Mon 17:00 P2/4OG

Voter model with recurrent mobility calibrated to Swedish data — •Attila Szilva[1] and Jérôme Michaud[2] — [1]Department of Physics and Astronomy, University of Uppsala, 752 37 Uppsala, Sweden — [2]Department of Sociology, University of Uppsala, 751 20 Uppsala, Sweden

In PHYSICAL REVIEW E 97, 062313 (2018), we have discussed the possible generalizations of the social influence with recurrent mobility (SIRM) model [Phys. Rev. Lett. 112, 158701 (2014)] by extended it for multiparty systems that are mathematically well-posed in case of extreme vote shares, too, by handling the noise term in a different way. The model is ready to apply for Swedish data, and preliminary results based on functional network analysis will be presented for the case of Sweden by analysing the spatial clustering of voting behaviour from 1985 to 2018.

SOE 6.2 Mon 17:00 P2/4OG

Policy and Innovation Spreading on the Global City Network — •Niklas Kitzmann[1], Xuemei Bai[2], Steven Lade[3], Ricarda Winkelmann[1], and Jonathan Donges[1] — [1]Potsdam Institute for Climate Impact Research, Germany — [2]Fenner School of Environment & Society, Australian National University, Canberra, Australia — [3]Stockholm Resilience Centre, Stockholm University, Sweden

Only a fast and global transformation towards decarbonization and sustainability can keep the Earth in a civilization-friendly state. Cities play an important role in this transformation: they are responsible for a dis-proportionally large part of greenhouse gas emissions, and simultaneously are one of the main drivers of sustainable policy innovation and adoption. Learning from each other to reduce, prepare for and react to the coming environmental changes, they can be conceptualized as nodes in a globe-spanning network. Such a network may be approximated by global air traffic, political and trade relations, and other city-to-city connections.

Here, we model the spreading of several municipal sustainability policies and innovations as contagion processes on such inter-city networks. For this purpose, several networks, comprised of different types of city interconnections, are extracted from empirical data. The spread of several urban technology and policy innovations, such as Bus Rapid Transit Systems and carbon neutrality targets, are then investigated to discover which network correlates best with the contagion process. Different hypotheses for the type of the contagion process are also tested, potentially yielding insights on social tipping dynamics.

SOE 6.3 Mon 17:00 P2/4OG

Simplicity as Ultimate Sophistication? — •Stephen I. Ternyik — POB.201 D-82043 Munich

There can be no doubt that the physical reality on our spaceship earth is extremely complex, with many complicated layers of interaction, concerning the empirical nature of human experiences.In the recent development of scientific methodology, computation has reached the research status level of experimental laboratory presicion and exactness, with artificial cognition (AI) and cognitive artifacts replacing real world applications (e.g. exponential medicine, in silico technologies).

In the economic sciences, we can observe the same methodical paradigm progress to beat complexity with even more complexity and to create virtual economic systems, which are extremely detached from everyday human economic action.The recommendations of Leonardo da Vinci and Albert Einstein, to formulate possible solutions to an existing problem in its most simplest degree, suggests that there are simple problem-solving techniques for complex tasks in science and life.

It is, therefore, very reasonable to assume that simplicity remains the ultimate sophistication, even in our tech-know-logical age of computational exponentiality, i.e. reducing and computing economic complexity into single working elements and to identify its dynamic interplay (matching tool and task intelligently). To paraphrase Ronald Coase, the data should not be tortured, until they confess to everything.

SOE 6.4 Mon 17:00 P2/4OG

Numerical study of phase transition and replica symmetry of bipartite z-matching — •Till Kahlke[1], Martin Fränzle[2], and Alexander K. Hartmann[1] — [1]Institut of Physics, University of Oldenburg, Germany — [2]Institut of Computer Science, University of Oldenburg, Germany

We study numerically [1] the many-to-one bipartite *z-matching*, a generalisation of the matching problem. It can be used, e.g., to model a wireless communication network of users and servers, where z denotes the maximum number of users a server can treat at one time. Within a bipartite graph representation, there are links from each user to all servers which are feasible, e.g., close enough. The maximum matching capacity of this graph is the largest total number of users all servers can serve. After mapping to standard maximum matching, we use a numerically *exact algorithm* (Edmonds blossom shrinking) to solve the z-matching problem. First, we compare it with previous analytic results [2]. Next, we look at the saturation probability as order parameter and *observe phase transitions* when varying the average number of neighbors. We describe these transitions by their critical points and an universal critical exponent. We also verify using a perturbation technique [3] that *replica symmetry* holds for this model.

[1] A.K. Hartmann, *Big Practical Guide to Computer Simulations* (World Scientific, 2015).
[2] E. Kreačić and G. Bianconi, Europhys. Lett. **126**, 28001 (2019).
[3] H. Schawe, J. Kumar Jha, and A.K. Hartmann, Phys. Rev. E **100**, 032135 (2019).

SOE 6.5 Mon 17:00 P2/4OG

Coupling strategies in spreading of SIS dynamics — •Felix Köster[1] and Fakhteh Ghanbarnejad[2,3] — [1]Institut für Theoretische Physik, TU Berlin, Hardenbergstraße 36, 10623 Berlin — [2]Department of Physics, Sharif University of Technology (SUT), Tehran, Iran — [3]Quantitative Life Sciences (QLS), The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy

Infectious diseases are of the most fatal threats in human history. Some recent studies have investigated the way interacting diseases become epidemic. In this work we consider two pathogenes each having two different strategies: cooperation or defection. By analysing the fundamental properties of the interacting contagious processes a well-mixed population, i.e. homogenous mean field approximation, new discontinous phase transitions are discovered. For a deeper understanding the parameters are altered and the change in the steady state solutions described. Using stochastic simluations we find multistabilites and show the relationships between the defective and cooperative pathogens.This work aims to improve our understanding of the natural dynamics of species populations in an evolutionary ecological framework.

SOE 6.6 Mon 17:00 P2/4OG

Demand responsive bimodal ride pooling systems: effects of network geometry — •Puneet Sharma[1,2], Stephan Herminghaus[1,2], and Knut Heidemann[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Dynamics of Complex Systems, University of Göttingen, Germany

Demand responsive ride pooling with minibuses is useful as a cheap door-to-door public transport, but leads to undue competition with line services, which provide much better pooling (average number of passengers per vehicle). A combination of both modes may provide an ideal solution, but is challenging to organize. We discuss various aspects of geometry of the involved networks affecting the efficiency of such systems. The geometry of the street network is found to strongly affect the poolability of routing requests to minibuses. The geometry and mesh size of the line service network is relevant for efficient combination with the minibus system. We find that for setting up an effective public transportation system, both aspects need to be optimized simultaneously.

SOE 6.7 Mon 17:00 P2/4OG

Analysis and control of multilayer, multi-timescale power grids — Lia Strenge[1], •Paul Schultz[2], Jörg Raisch[1], and Frank Hellmann[2] — [1]Potsdam Institute for Climate Impact Research (PIK), 14473 Potsdam, Germany — [2]Control Systems Group, Technische Universität Berlin, Germany

Power systems are subject to fundamental changes due to the increasing infeed of decentral renewable energy sources and storage. The decentral nature of the new actors in the system requires new concepts for structuring the grid, and achieving a wide range of control

tasks ranging from seconds to days. Here we introduce a multilayer dynamical network model covering all control time scales. Crucially we combine a decentral, self-organised low-level control and a smart grid layer of devices that can aggregate information from remote sources. The stability-critical task of frequency control is performed by the former, the economic objective of demand matching dispatch by the latter. Having both aspects present in the same model allows us to study the interaction between the layers. Remarkably we find that adding communication in the form of aggregation does not improve the performance in the cases considered. Instead the self-organised state of the system already contains the information required to learn the demand structure in the entire grid. The model introduced here is highly flexible, and can accommodate a wide range of scenarios relevant to future power grids. We expect that it will be especially useful in the context of low-energy microgrids with distributed generation.

SOE 6.8 Mon 17:00 P2/4OG

Demand Responsive Ride Pooling: Theory, Simulation, Experiment — •Felix Jung and Stephan Herminghaus — Max Planck Institute for Dynamics and Self-Organization, 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 further in the context of experimental data and computer simulations [2].

[1] Herminghaus, Transportation Research Part A **119** (2019)
[2] Sorge et al., Proceedings of the 2015 Winter Simulation Conference

SOE 6.9 Mon 17:00 P2/4OG

Evaluation of Demand Responsive Ride Pooling on Real Life Taxi Data — •Michael Sternbach[1,2], Felix Jung[1,2], Puneet Sharma[1,2], Stephan Herminghaus[1,2], and Knut Heidemann[1,2] — [1]Max Planck Institute for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Dynamics of Complex Systems, University of Göttingen, Germany

Climate change caused by human greenhouse gas (GHG) emissions is one of the vital challenges of humankind. Passenger cars contribute significantly to human GHG emissions. To reduce this effect, more eco-friendly transport modes are needed. Demand responsive ride pooling (DRRP) offers door-to-door service — similar to taxi or personal car — while pooling customers with similar routes on the same vehicle, thereby reducing emissions and the number of cars needed. In this study, we measure the performance of a DRRP system on real life taxi request data and evaluate under which conditions — e. g. request rate, number of vehicles, allowed detour or waiting time — DRRP can operate more efficiently than taxi service at a reasonable service quality. We compare our results to a mean field description of DRRP [1] to analyze the effect of road network structure and spatial request distribution. Our results provide significant insight on the prerequisites for ecological and economic feasibility of DRRP.

[1] Herminghaus, S. (2019). Mean field theory of demand responsive ride pooling systems. Transportation Research Part A: Policy and Practice, 119, 15-28.

SOE 6.10 Mon 17:00 P2/4OG

Comparing spatial distributions of population and stores/facilities based on multifractal analysis — •Mariko Ito and Takaaki Ohnishi — The University of Tokyo, Tokyo, Japan

By multifractal analysis, we can characterize the structural feature of an object in which the density is spatially heterogeneous. The multifractal spectrum obtained from the analysis shows the relationship between the local fractal dimension (singularity strength) and the fractal dimension of all points that have the singularity strength around each of those. We applied multifractal analysis to the investigation on how the population and stores/facilities distribute spatially in the metropolitan area in Japan. As the data of the population and stores/facilities, we used Japanese 100-meter estimated mesh data from national censuses and corporate telephone directory database telepoint with coordinates, respectively.

We derived the multifractal spectrums for the spatial distribution of the population and 39 categories of stores/facilities. We compared the spectrums of the population and the categories, by using the indicators relating to the shape of each spectrum, such as the width of the singularity strength of the spectrum. In this presentation, we will show what kind of stores/facilities possess similar multifractal spectrum to that of the population. We will discuss which categories of stores/facilities are close to the population in the point of view of the spatial distribution.

SOE 6.11 Mon 17:00 P2/4OG

Transition from Hierarchical to Distributed Verification Protocols: Consensus Formation in Transforming Network Topologies — Kateryna Isirova[1,2], Oleksandr Potii[2], and •Jens Christian Claussen[1] — [1]Department of Mathematics, Aston University, Birmingham B4 7ET, U.K. — [2]V. N. Karazin Kharkiv National University, Ukraine

Computer verification protocols are distributed processes on networks and have the goal of reaching an overall consensus state where all nodes become verified through a protocol interaction. An important goal is to ensure the security of such interactions, especially in advent of quantum computing technologies. It might be that in the post-quantum world, the avatar of verification architectures will be manifested through distributed protocols. Here we augment the discussion by explicitely drawing the analogy between distributed protocol consensus formation and consensus formation in social networks in various topologies. Hierarchical networks, in both domains, exhibit slowest timescale of consensus formation. We conclude this supports universal argument towards establishment of distributed protocol mechanisms, wherever the scaleability with network size is of relevance.

SOE 6.12 Mon 17:00 P2/4OG

A model of public opinion with time-dependent media bias, audience attention and social influence. — •Michael Schnabel and Daniel Diermeier — Harris School of Public Policy, University of Chicago, USA

We consider a simple model of binary opinions. Individuals form their opinion based on individual preferences, time dependent media bias and the overall opinions in the population. In addition, we also incorporate a mechanism that is responsive to the salience of the media signal and can be used to account for variations in public attention. We explore how attention affects the opinion dynamics in the population as well as the equilibrium properties in a hypothetical static environment.

SOE 6.13 Mon 17:00 P2/4OG

Masking Motifs in Networks of Coupled Oscillators — •Jonas Wassmer[1,2], Franz Kaiser[1,2], 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

Electric power grids, vascular networks in leaves and neuronal networks in the human brain are examples of complex networks which are subject to fluctuations. Local changes in the underlying dynamics may affect the whole network and, in the worst case, cause a total collapse of the system through a cascading failure. However, certain network motifs exist, which effectively decouple different network modules and thus reduce failure spreading drastically, or even inhibit it completely. In this contribution we review the function of network isolator motifs for linear flow networks and investigate their operation for non-linear network dynamical systems, such as Kuramoto networks. We demonstrate how these network motifs can hide the source of a perturbation and discuss how they may be applied to improve the robustness of different types of networks.

SOE 6.14 Mon 17:00 P2/4OG

Machine Learning Applications in Energy Research — •Omar El Sayed, Alexander Kies, and Horst Stoecker — Frankfurt Institute for Advanced Studies, Frankfurt, Germany

In recent years, machine learning has received considerable attention in different fields of research. Machine learning provides efficient tools for different applications with respect to energy research. Different applications of machine learning in the field of energy research include:

- forecasting of relevant quantities for power systems such as de-

mand, renewable generation, electricity prices - grid optimisation, monitoring and control - smart future market mechanism based on novel paradigms - accurate energy system modelling, for instance via weather data analysis and generation.

In this work, we show and discuss exemplary applications.

SOE 6.15 Mon 17:00 P2/4OG

Optimal transport flow networks with a linear congestion model — •Matthias Dahlmanns[1,2], Franz Kaiser[1,2], and Dirk Witthaut[1,2] — [1]Forschungszentrum Jülich, Institute for Energy and Climate Research (IEK-STE), 52428 Jülich, Germany — [2]Institute for Theoretical Physics, University of Cologne, 50937 Köln, Germany

In our daily life, we rely on the proper functioning of various types of supply networks, such as power grids, water supply networks or transportation networks. But what determines the optimal structure of such networks, i.e. how should they be designed? And what happens to them in case of link failures or damages?

A variety of analytical results are available for optimal structures and the response to damages for shortest path flow networks on the one hand and potential flow networks, such as electrical power grids, on the other hand.

In a transportation network, however, travelers try to minimise their travel time, but congestion effects occur on highly frequented links due to limited capacity.

In this contribution, we introduce an approach to study the congestion by a travel time that depends linearly on the local flow which leads to a combination of the two well studied flow types. We then focus on the impact of link failures in this interpolating model and analyse the transition between both flow types in detail. Our results can be applied to understand the influence of congestion on the design of optimal traffic flow networks.

SOE 6.16 Mon 17:00 P2/4OG

Die Benutzung der Mathematischen Begriffstheorie von E. Wojschwillo für Analyse der Parteisystemen — •Alexey Iakovlev[1] und Ekaterina Pchelko-Tolstova[2] — [1]TU Dresden, Dresden, Deutschland, RUDN University, Moscow, Russia — [2]RUDN University, Moscow, Russia

Im 21. Jahrhundert gibt es kaum politische Systemen ohne Parteien. Diese Parteien unterscheiden sich voneinander nach den ideologischen Grundlagen ihrer Tätigkeit. Die Ideologie ist meistens als die Grundlage der Klassifizierung der Parteien benutzt. Wenn sie zugeordnet sind, so bilden sie das politische Spektrum. Die Ideologie besteht aus vielen Teilen: Wirtschaftspolitik, Sozialpolitik, Kulturpolitik usw. In der globalisierten Welt bilden mehrere Parteien aus untershiedlichen Ländern die Bündnissen. Sie verbinden sich miteinander nach der Ideologie. Die Politikwissenschaftler und politische Berater prognostizieren die Politik der Länder nach den Wahlergebnissen. Das Problem ist aber, dass oft die Parteien, die als ähnliche bezeichnet wurden, oft ganz unterschiedlich in unterschiedlichen Ländern sind.

Der sowjetische Mathematiker,Logiker und Philosoph Jewgeni Kazimirowitsch Wojschwillo entwickelte seit der 1960-er Jahren die mathematisierte Lehre über den Begriff,die Beziehungen zwischen den Mengen und ihre Klassifizierung zuordnet. Die Benutzung der Mengendiagrammen bei der Arbeit mit den Begriffen und der Definitionen zeigt, welche Parteien zu welchen passen und welche tatsächlich ganz unterschiedlich sind. Das verbessert die Qualität der Prognosen der Dynamik der politischen Systemen.

SOE 6.17 Mon 17:00 P2/4OG

African Swine Fever - potential topic of awareness in social movements — •Andrzej Jarynowski and Vitaly Belik — Institute for Veterinary Epidemiology and Biostatistics, FU Berlin

African Swine Fever (ASF) is a viral infection in domestic pigs and wild boars causing more than one billion EUR yearly losses in Eastern Europe. To illustrate the impact, only in Poland, after introduction in 2014, due to restrictions ca. 90% of farms stopped pig production or were banned. The intensive control measures against ASF in European Union significantly transforms biosecurity, trade, sanitary, environmental etc. regulations and ethics, thus causing protests of various groups of interest as (1) farmers (who are not ready to apply biosecurity measures), (2) animal right defenders (who do not agree with governmental policy of wild boars depopulation) and (3) hunters with public administration (who have to control wild boars population). We analyze ASF topic awareness in the Internet in Poland and Germany. In particular, we reviewed possibility of using Twitter and Facebook data on ecological, animal rights activism, farmers association as well hunters and veterinarians organisations. We showed by using retweeting and following networks from Polish twitter, that meaningfull clusters of agents can be detected. The possible appearance of political consultancy or foreign intelligence in social media, which could polarize society, were observed because Twitter accounts, already classified as potentially suspicious were also propagating anti-government content which fueled animal right movement.

SOE 6.18 Mon 17:00 P2/4OG

Impact of temporal correlations on high risk outbreaks — •Sina Sajjadi, Mohammad Reza Ejtehadi, and Fakhteh Ghanbarnejad — Sharif University of Technology, Tehran, Iran

In this work, we first propose a quantitative approach to detect high risk outbreaks of independent and coinfective SIR dynamics on three empirical networks: a school, a conference and a hospital contact network. This measurement is based on the k-mean clustering method and identify proper samples for calculating the mean outbreak size and the outbreak probability. Then we study systematically impact of different temporal correlations on high risk outbreaks by different shuffling. We observe that in the coinfection process, randomization of the sequence of the events makes the outbreak, i.e. the mean outbreak size of high risk cases, more pervasive. On the other hand these correlations don't have a consistent effect on the independent infection dynamics, and can either decrease or increase this mean. Our results suggest that some sort of randomizing contacts in organization level of schools, events or hospitals might help to suppress the spreading dynamics while the risk of an outbreak is high.

SOE 6.19 Mon 17:00 P2/4OG

Exact solution of generalized cooperative susceptible-infected-removed (SIR) dynamics — •Fatemeh Zarei[1], Saman Moghimi-Araghi[1], and Fakhteh Ghanbarnejad[1,2,3] — [1]Sharif University of Technology, Tehran, Iran — [2]ITP, Technical University of Berlin, Germany — [3]The Abdus Salam International Centre for Theoretical Physics (ICTP), Trieste, Italy

In this paper (Phys. Rev. E 100, 012307 (2019)), we introduce a general framework for coinfection as cooperative susceptible-infected-removed (SIR) dynamics. We first solve the SIR model analytically for two symmetric cooperative contagions [L. Chen et al., Europhys. Lett. 104, 50001 (2013)] and then generalize and solve the model exactly in the symmetric scenarios for three and more cooperative contagions. We calculate the transition points and order parameters, i.e., the total number of infected hosts. We show that the behavior of the system does not change qualitatively with the inclusion of more diseases. We also show analytically that there is a saddle-node-like bifurcation for two cooperative SIR dynamics and that the transition is hybrid. Moreover, we investigate where the symmetric solution is stable for initial fluctuations. We finally explore sets of parameters which give rise to asymmetric cases, namely, the asymmetric cases of primary and secondary infection rates of one pathogen with respect to another. This setting can lead to fewer infected hosts, a higher epidemic threshold, and also continuous transitions. These results open the road to a better understanding of disease ecology.