

SOE 10: Focus Session: Complex Contagion Phenomena (joint session SOE / DY / BP)

Complex contagion is the phenomenon in nature in which multiple factors are required for an agent in order to adopt or/and change of a behavior. Generically pathogens, information, opinions, new technologies that spread and proliferate on networks (e.g. contact networks between individuals in single populations or in networks of populations that are coupled by means of transportation, etc) interact, coexist and coevolve. These can effectively change simple dynamical processes to complex contagion phenomena. This session addresses the theoretical approaches as well as empirical studies dealing with these phenomena. (Session compiled and chaired by Fakhteh Ghanbarnejad and Dirk Brockmann.)

Time: Tuesday 10:15–13:15

Location: MA 001

Topical Talk SOE 10.1 Tue 10:15 MA 001

Micro dynamics of social interactions — ●SUNE LEHMANN — Technical University of Denmark, Kgs Lyngby, Denmark

Over the past decade, we have made tremendous progress in understanding the complex networks in the world around us. In terms of social systems, we have recently developed the technological ability to measure the dynamics such networks with unprecedented accuracy, using smartphones as sensors.

For the past two years, my group has worked towards creating a dataset of unparalleled quality and size. We use smartphones as measurement devices to capture the complete network (face-to-face, telecommunication, online social networks, geolocation, etc) in a group of approximately 1000 individuals. In terms of size, this increases the number of study participants by a full order of magnitude compared to similar studies in the field.

I'll give an overview of our ongoing work with a particular focus on spreading processes as well as communities in face-to-face networks.

SOE 10.2 Tue 10:45 MA 001

Cooperative SIS epidemics can lead to abrupt outbreaks — ●FAKHTEH GHANBARNEJAD¹, LI CHEN², WEIRAN CAI³, and PETER GRASSBERGER⁴ — ¹Max Planck Institute for the Physics of Complex Systems, Dresden, Germany — ²Robert Koch- Institute, 13353 Berlin, Germany — ³TU Dresden, Germany — ⁴JSC, FZ Jülich, D-52425 Jülich, Germany

In this paper, we study spreading of two cooperative SIS epidemics in mean field approximations and also within an agent based framework. Therefore we investigate dynamics on different topologies like Erdos-Renyi networks and regular lattices. We show that cooperativity of two diseases can lead to strongly first order outbreaks, while the dynamics still might present some scaling laws typical for second order phase transitions. We argue how topological network features might be related to this interesting hybrid behaviors.

SOE 10.3 Tue 11:00 MA 001

How to quantify the strength of factors in a contagion phenomena? — FAKHTEH GHANBARNEJAD, MARTIN GERLACH, JOSE M. MIOTTO, and ●EDUARDO G. ALTMANN — Max Planck Institute for the Physics of Complex Systems, Dresden

Different factors contribute to the spreading of a process through a population. For instance, the adoption of an innovation may depend on factors such as peer pressure, agent specific beliefs, and the intrinsic fitness of the innovation. In this talk we (i) introduce a measure of the contribution of a factor to the overall spreading; (ii) show how this measure depends on the spreading dynamics (e.g., Bass or Threshold) and network topology; and (iii) propose methods to estimate the strength of factors from data.

[1] F. Ghanbarnejad, M. Gerlach, J. M. Miotto, and E. G. Altmann, "Extracting information from S-curves of language change", J. R. Soc. Interface 11, 20141044 (2014)

SOE 10.4 Tue 11:15 MA 001

Competitive percolation: How cooperation can strengthen competitors — LI CHEN^{1,2} and ●DIRK BROCKMANN^{1,2} — ¹Robert-Koch Institute, Berlin, Germany — ²Humboldt University, Berlin, Germany

Competition and cooperation are ubiquitous in natural and social systems. Typically, both concepts are considered as antagonistic and mutually exclusive dynamic forces that typically enter systems as independent degrees of freedom with opposite signs. Direct interactions of both concepts, e.g. the benefit of cooperation among competitors and vice versa, is less well understood. Here we investigate a net-

work system, in which two choices initially compete with for individual agents in a susceptible population. Cooperation enters the system by enhanced recruitment in a secondary contagion process for those individuals that recovered from the first reaction. A mean-field analysis supplemented with agent-based simulations shows that these systems can exhibit a discontinuous transition for the contagion process for strong cooperativity. We also show that one "infection" only survives in the presence of the other. Our model can shed light on the dynamics of systems in socio-economic contexts, sports and stability of fashion traits.

SOE 10.5 Tue 11:30 MA 001

The good, the bad and the optimal: allocation of resources during emergent infectious diseases — ●OLGA BARANOV¹ and DIRK BROCKMANN^{1,2} — ¹Robert Koch Institut, Berlin — ²HU Berlin

The growing complexity of global mobility is a key challenge for the understanding of the worldwide spread of emergent infectious diseases and the design of effective containment strategies. Despite global connectivity, containment policies are based on national, regional and 'egocentric' assessments of outbreak situations that are no longer effective or meaningful in the development of efficient containment strategies. This was recently demonstrated by 2014 Ebola outbreak in West Africa where months passed before a concerted effort followed. Despite the importance of the matter, optimal strategies are poorly understood. We investigate a model for the optimal deployment of mitigation resources in a network of interacting countries. Each node can exercise a limited amount of resources among all nodes in the network to mitigate an outbreak. At each node costs are a combination of invested resources and effective susceptibility to import a disease. We treat the problem game theoretically and show that, contrary to common belief, purely selfish and cooperative actions do not differ considerably in a single outbreak scenario. Purely selfish behavior tends to invest resources at the outbreak location. However, in a scenario with multiple outbreak locations we find that resource allocation can follow more complex patterns and nodes can fall back on egocentric resource allocations. We will report on preliminary results obtained for a system when disease dynamics and resource allocation are modelled explicitly.

Topical Talk SOE 10.6 Tue 11:45 MA 001

Containing epidemics using limited resources and information — ●OLIVIA WOOLLEY-MEZA — Computational Social Science, ETH Zurich, Clausiusstrasse 37, CLD C6

Every action taken to contain disease spread carries a potential payoff but also a cost. Can we successfully contain epidemic spreading when resources are limited, and decisions on how to allocate these resources are based on imperfect information? I will discuss two cases where the interaction of economic constraints with disease spread transforms the spreading dynamics, usually making it harder to contain the disease. However, I will show that some constraints can work to our advantage. I first consider the dynamics of an epidemic when the recovery of sick individuals depends on the availability of healing resources that are generated by the healthy population. Epidemics spiral out of control into "explosive" spread if the cost of recovery is above a critical cost. The transition to this explosive regime is discontinuous – once there are signs of a transition it can no longer be prevented. In the second case I will show you how the information resolution available to individuals determines the effectiveness of voluntary vaccination decisions. Although an epidemic cannot be contained when individuals use global information, the successful eradication of a disease can occur in an intermediate region of information resolution between the local and the global.

SOE 10.7 Tue 12:15 MA 001

Virus transmission on a network of injecting drug users — ●CORNELIA METZIG and PETER WHITE — Department of Infectious Disease Epidemiology, Imperial College London, UK

The Hepatitis C virus (HCV) is a virus that is most prevalent among injecting drug users, who transmit the virus by sharing their injecting equipment, a problem that receives much attention from healthcare providers. Several studies investigate the topology of drug injecting partners via snowball sampling methods with the goal of describing a static network. Typical networks are reported to be highly clustered, assortive and heavy-tailed in degree distribution. Transmission dynamics of the virus can be described by SIR or SIS-models, depending whether treatment is considered.

In addition, virus transmission is affected by (i) change in sharing partners, and (ii) entry and exit from the community, which happen at shorter timescales than the duration of an untreated infection is. These phenomena can be captured in a network model where each connection describes only one sharing event. Simultaneous rewiring of the network and transmission are studied theoretically and numerically in a model. Assumptions on the network, HCV-incidence rate and HCV-prevalence are compared to data on drug users from the UK.

SOE 10.8 Tue 12:30 MA 001

Spatio-temporal dynamics of the cholera epidemic of 1831/1832 in Austria — ●MICHAEL LEITNER¹ and GERO VOGL² — ¹Heinz Maier-Leibnitz Zentrum (MLZ), Technische Universität München, Lichtenbergstr. 1, 85748 Garching, Germany — ²Fakultät für Physik, Universität Wien, Boltzmanngasse 5, 1090 Wien, Austria

Caused by large-scale troop movements in the Russian empire, cholera reached Europe in 1830 and caused the first cholera pandemic to affect the western world. Within the confined region of Weinviertel in Lower Austria (approx. 5000 km²), first cases were registered in 1831, while major outbreaks followed in the summer months of 1832. We reconstructed the dynamics of the disease from the causes of death in the clerical burial records on the temporal scale of single days and spatial scale of single villages. We analyze the data in terms of connectivity, both concerning geographical distance and bodies of flowing water. In contrast to analyzes of recent epidemics, we hope to obtain

finer-resolution information on the dynamics due to the lower human mobility in past times.

SOE 10.9 Tue 12:45 MA 001

Containment of contagious processes on temporal networks via adaptive edge rewiring — ●VITALY BELIK^{1,2}, FLORIAN FIEBIG¹, and PHILIPP HÖVEL¹ — ¹Institut für Theoretische Physik, TU Berlin — ²Helmholtz-Zentrum für Infektionsforschung, Braunschweig

We consider a recurrent contagious process spreading on a time-varying network topology. As a containment measure we propose an adaptive rewiring mechanism: after detection of the disease, to temporary isolate infected nodes, rewiring the incoming edges away from those nodes. As a case study we use the network of animal trade in Germany. One of the main results reveals heterogeneous performance of adaptation in respect to different index nodes (where epidemic initially started): some index nodes lead to easily controllable epidemics and some not. Our findings are important for designing response strategies for infectious diseases management.

SOE 10.10 Tue 13:00 MA 001

Spread of Infections on Temporal Networks — ●ANDREAS KOHER, LUCIAN WILLARETH, HARTMUT LENZ, and IGOR M. SOKOLOV — Humboldt University, Berlin

Social interactions can be naturally abstracted to temporal networks, where bonds appear as long as the corresponding contacts exist. In epidemiological studies the temporal dimension is usually projected out however, in order to apply the standard tools from (static) network analyses even though, a systematic error will be introduced thereby. We present an intuitive algebraic formalism by contrast, which is explicitly based on temporal networks and which allows to calculate potential paths of an infection. By applying the idea to a SIR (susceptible-infected-recovered) type of disease, we will present an elegant way to find all possibly affected nodes of an outbreak. The method can be efficiently implemented and will be demonstrated on a recorded data set.