# AGSOE 17: Networks: From Topology to Dynamics II

Time: Thursday 10:15–12:45 Location: BAR 205

AGSOE 17.1 Thu 10:15 BAR 205

**Universality and the lack of it in multiscale human mobility networks** — •Rafael Brune[1,2], Christian Thiemann[1,2], and Dirk Brockmann[1] — [1]Northwestern University, Evanston IL, USA — [2]Georg-August-Universität, Göttingen, Germany

Although significant research effort is currently devoted to the understanding of complex human mobility and transportation networks, their statistical features are still poorly understood. Specifically, to what extent geographical scales impose structure on these networks is largely unknown. In particular, in light of the use of human mobility models in the development of quantitative theories for spatial disease dynamics, a comprehensive understanding of their structure is of fundamental importance. The large majority of statistical properties (degree distributions, centrality measures, clustering, etc.) of these networks have been obtained either for large scale networks or on small scale systems, indicating significant yet poorly understood deviations. We will present the first investigation of multiscale and multi-national mobility networks, covering length scales of a few to a few thousand kilometers. We will report that certain properties such as mobility flux distribution are universal and independent of length scale, whereas others vary systematically with scale. In particular, controversial properties such as scale-free degree distributions lose their heavy tails in small to intermediate length-scale windows.

AGSOE 17.2 Thu 10:45 BAR 205

**About human activity, long-term memory, and Gibrat's law** — •Diego Rybski[1], Sergey V. Buldyrev[2], Shlomo Havlin[3], Fredrik Liljeros[4], and Hernan A. Makse[1] — [1]Levich Institute and Physics Department, City College of New York, New York, NY 10031, USA — [2]Department of Physics, Yeshiva University, New York, NY 10033, USA — [3]Department of Physics, Bar-Ilan University, Ramat-Gan 52900, Israel — [4]Department of Sociology, Stockholm University, S-10691 Stockholm, Sweden

A central research question in the social sciences for several centuries has been whether any law like patterns in the unintended outcomes of human action exist. Here we investigate the existence of scaling laws in the human activity of communication, considering the number of messages sent by individuals as a growth process in time. We analyze millions of messages sent in two social online communities and uncover power-law relations between fluctuations in the growth rate and the activity of the members. We attribute this scaling law to a long-term persistence of human activity beyond daily or weekly cycles holding up to more than a year. Based on such an underlying long-term correlated dynamics, we elaborate a consistent framework for the empirical evidences, establishing a missing link between the scaling behavior in the growth and long-term persistence. Our results indicate that large fluctuations in communication activity can be expected as an unintended consequence of human interaction. This finding is of importance for both designing communication systems and for understanding the dynamics of social systems.

AGSOE 17.3 Thu 11:15 BAR 205

**Patterns of cooperation** — •Anne-Ly Do and Thilo Gross — Max Planck Institute for the Physics of Complex Systems, Dresden

We propose a simple model for the formation of cooperation networks among self-interested agents. It bases on the continuous snowdrift game, a paradigmatic approach to cooperation studied by different disciplines, but replaces non-directional cooperativeness by the ability of humans to maintain different levels of cooperation with different, self-chosen partners. The model reproduces and provides a rationale for well known phenomena from biology, anthropology, sociology, politics, and economics. Its twofold nature opens rich potentialities for the analytical treatment: The underlying differential equations allow for a stability analysis by means of dynamical systems theory. The discrete nature of the evolving network enable the application of graph theoretical tools. All told makes the model a promising candidate for a unified framework for phenomena from several disciplines.

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**Dynamics of a SIRS epidemic model on an adaptive network** — •Alejandro Mora[1,2], Gerd Zschaler[1], and Thilo Gross[1] — [1]Max-Planck Institute for the Physics of Complex Systems, Nöthnitzer Straße 38, 01187 Dresden Germany — [2]Simulation of Physical Systems Group, Departamento de Física, Universidad Nacional de Colombia, Cra 30 45-03, Ed. 404, Of. 348, Bogotá D.C., Colombia

The study of epidemic spreading on adaptive networks combine tools from the classical epidemiology, statistical physics, and dynamical systems theory. Adaptive evolution of the network topology depending on the local state of the nodes provides a more realistic approach to the propagation of contagious diseases. We investigate the dynamics of a *susceptible-infected-recovered-susceptible* (SIRS) epidemiological process on an adaptive network. The recovered state is proposed to represent either temporal immunity or susceptible population turnover. In the latter case, a node in the recovered state loses its links at a fast rate, while new links are permanently created and destroyed between nodes in the other epidemiological states. We analyze the system behavior with extended mean-field equations that include links between nodes as dynamical variables and a moment closure that approximates higher order correlations between nodes. The numerical solutions of such correlation equations show the emergence of discontinuous transitions, bifurcations, and oscillations of the disease prevalence. Then comparisons are performed with analogous results of intensive agent-based simulations on networks. Finally, we discuss application to real epidemics.

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**Optimization of AS Internet Robustness to Malicious Attack** — •Christian M. Schneider[1], Andre A. Moreira[2], Jose S. Andrade Jr.[2], Shlomo Havlin[3], and Hans J. Herrmann[1,2] — [1]Computational Physics, IfB, ETH-Hönggerberg, Schafmattstrasse 6, 8093 Zürich, Switzerland — [2]Departamento de Física, Universidade Federal do Ceará, 60451-970 Fortaleza, Ceará, Brazil — [3]Minerva Center and Department of Physics, Bar-Ilan University, 52900 Ramat-Gan, Israel

We develop a method that substantially improves the robustness of complex networks against malicious attacks. This technique is successfully applied for the Internet at the level of autonomous system and other scale-free networks. As malicious attack we choose the dynamic degree-based attack and we numerically optimize the network under the condition that the degree distribution remains invariant. We also study three different types of scale-free network models and compare the results with the real network.