# SOE 13: Symposium SYCM: Physics of Collective Mobility (SOE / DY / BP / jDPG)

Time: Wednesday 9:30–12:15 Location: HSZ 02

**Invited Talk** SOE 13.1 Wed 9:30 HSZ 02

**Mobility in shareability networks** — •Michael Szell — Centre for Social Sciences, Hungarian Academy of Sciences, Országház utca 30, 1014 Budapest, Hungary — Center for Network Science, Central European University, Nador utca 11, 1051 Budapest, Hungary — Center for Complex Network Research, Northeastern University, 177 Huntington Avenue, 02115 Boston, USA — moovel lab, Haupstätter Straße 149, 70178 Stuttgart, Germany — Senseable City Lab, MIT, 77 Massachusetts Ave, 02139 Cambridge, USA

We introduce the notion of shareability network, which allows us to model the collective benefits of sharing trips as a function of passenger inconvenience, and to efficiently compute optimal sharing strategies on massive datasets. We apply this framework to a dataset of millions of taxi trips taken in New York City, showing that cumulative trip length can be cut by 40%. This benefit comes with reductions in emissions and split fares, hinting toward a wide passenger acceptance. Shareability as a function of trip density saturates fast, suggesting effectiveness of the taxi sharing system also in cities with much sparser taxi fleets. We compute the shareability curves in several further world cities, and find that a natural rescaling collapses them onto a single, universal curve. We explain this scaling law with a simple model that predicts the potential for ride sharing in any city, using a few basic urban quantities and no adjustable parameters. Finally, we demonstrate how interactive data visualizations of re-ordered city spaces can effectively inform relevant stakeholders and the public about large-scale reductions of parking spaces in future scenarios of wide-spread car-sharing.

**Invited Talk** SOE 13.2 Wed 10:00 HSZ 02

**Trail-following bacteria: from single particle dynamics to collective behaviour** — Anatolij Gelimson[1], Kun Zhao[2,3], Calvin K. Lee[3], W. Till Kranz[1], Gerard C. L. Wong[3], and •Ramin Golestanian[1] — [1]Rudolf Peierls Centre for Theoretical Physics, University of Oxford, Oxford OX1 3NP, United Kingdom — [2]Key Laboratory of Systems Bioengineering, Ministry of Education, School of Chemical Engineering and Technology, Tianjin University, Tianjin, 300072, People's Republic of China — [3]Bioengineering Department, Chemistry & Biochemistry Department, California Nano Systems Institute, UCLA, 90095-1600, Los Angeles, CA, USA

Can we learn from bacteria how to coordinate our mobility, and navigate our way towards mutually beneficial collective states? Trail-following bacteria leave behind precious exopolysaccharides as marker of where they been, and use it to accelerate the formation of colonies. We study this phenomenon, by building a stochastic microscopic model for the pili-driven motility of bacteria that interact with trails which could be laid by themselves and others. We discuss its phenomenology both at the level of single bacterium dynamics and collective self-organization into colonies. We validate the model using Pseudomonas aeruginosa trajectories, and show that fitting the parameters at the single bacterium level leads to a good quantitative agreement between the predictions of the model for the collective behaviour of the colony and the corresponding experimental observations.

**Invited Talk** SOE 13.3 Wed 10:30 HSZ 02

**Mobility and Self-Organization in Multi-Layer Networks: A Meta-Foodweb example** — •Thilo Gross[1], Andreas Brechtel[2], Philipp Gramlich[2], Daniel Ritterskamp[1], and Barbara Drossel[2] — [1]Department of Engineering Mathematics, University of Bristol, Bristol, UK — [2]Institut für Festkörperphysik, TU Darmstadt, Darmstadt, Germany

The emergence of structures and patterns from diffusive motion has long fascinated scientists. This phenomenon is best known from systems in continuous space. In this talk I will propose a general approach for the study of such phenomena in certain multi-layer networks.

I focus on the example of ecological meta-foodwebs, which describe the dispersal of animals across a fragmented landscape. Each individual undergoes diffusive motion on a network where the nodes are habitats and the links are routes of potential migration. Furthermore, the individuals are subject to predator-prey interactions with other individuals, described by a complex food web. The meta-foodweb thus constitutes a large multiplex network-on-network system.

To study the onset of self-organized pattern formation I consider the dynamical stability of steady states. By exploiting the structure of the system it is possible to separate the effects of the food-web and the geographical network and write a master stability function for the system. The result is a reduced system that bears a remarkable resemblance to pattern forming systems in continuous space, but has much richer behaviour.

**15 min. break**

**Invited Talk** SOE 13.4 Wed 11:15 HSZ 02

**Temporal Percolation in Critical Collective Mobility Systems** — •Andreas Sorge[1,2,4], Debsankha Manik[1,2], Jan Nagler[3,4], and Marc Timme[1,2,4] — [1]MPI for Dynamics and Self-Organization, Göttingen, Germany — [2]Institute for Nonlinear Dynamics, Georg-August-Universität, Göttingen, Germany — [3]Computational & Theoretical Physics, IfB, ETH Zürich, Switzerland — [4]Organization for Research on Complex Adaptive Systems (or-cas), Göttingen, Germany

A collective mobility system is a stochastic dynamical system that operates under opposing objectives. Its function is to both satisfy individual mobility demand in a timely fashion and make efficient use of the available transport vehicles. To understand and design such a system, one must study, devise and assess dispatching rules that bundle individual requests and assign them to vehicles. If overall mobility demand exceeds capacity, the system congests and ceases to function. Determining the capacity is henceforth crucial to assess any given dispatching rule and inform system design for optimized system performance and individual utility. Intriguingly, the brink to congestion constitutes a critical transition reminiscent of percolation in time. We develop a dynamic notion of criticality of such stochastic processes, mapping return times to spatial clusters of percolation theory. We present a method to algorithmically determine the critical point and exponents and its application to collective mobility systems in this temporal percolation paradigm.

**Invited Talk** SOE 13.5 Wed 11:45 HSZ 02

**Modeling the evolution of cities** — •Marc Barthelemy — IPhT/CEA, Saclay, France — CAMS/EHESS, Paris, France

The recent availability of data about cities and urban systems opens the exciting possibility of a 'new Science of Cities'. Urban morphogenesis, activity and residence location choice, mobility, urban sprawl and the evolution of urban networks are just a few of the important processes that can be discussed now from a quantitative point of view. In this talk, I will discuss how a data-informed approached can elaborate on urban economics models in order to get predictions in agreement with empirical observations. I will illustrate this approach on the growth of cities and the emergence of a polycentric structure of activity centers. I will conclude by highlighting some important challenges and possible research directions.