TUT 2: Stochastic Processes from Financial Risk to Dynamics in Biology and Physics (joint session SOE/DY/TUT)

Stochastic Processes are an essential ingredient of models in biology, physics and chemistry, as well as in socio-economic systems where agents are often modeled by a simple set of rules. The tutorials first lay foundations, then introduce advanced concepts and finally demonstrate their application in turbulence, critical phenomena in socio-technical networks, and the dynamics of epidemic spreading. (Session organised by Jens Christian Claussen.)

Time: Sunday 16:00–18:30 Location: HSZ 03

Tutorial TUT 2.1 Sun 16:00 HSZ 03

Stochastic models for particles in turbulence — •Bernhard Mehlig — Department of Physics, University of Gothenburg, Sweden

The subject of this tutorial is the dynamics of heavy particles in turbulence, such as water droplets in the turbulent air of a cumulus cloud, dust grains in the turbulent gas around a growing star, or motile microorganisms in the turbulent ocean. The analysis of such highly nonlinear and multi-scale problems poses formidable challenges, because any description of the dynamics must refer to the turbulent fluctuations that the particles experience as they move through the fluid. Experiments resolving the particle dynamics have only recently become possible, and direct numerical simulations of such systems are still immensely difficult.

In this tutorial I explain how to understand the fundamental mechanisms determining the dynamics of particles in turbulence in terms of statistical models that account for the symmetries and statistics of the turbulent flow. Using simple examples I illustrate how to solve such models with diffusion approximations, highlighting an analogy with Kramers' escape problem. I discuss the limitations of the approach, and summarise recent progress. I conclude by discussing open questions, arguing that the approach outlined provides a unique opportunity to make significant progress regarding this challenging and important problem.

Tutorial TUT 2.2 Sun 16:50 HSZ 03

From Percolation and Explosive Percolation to a unifying principle — •Jan Nagler — Frankfurt School of F&M, Frankfurt, Germany

The emergence of large-scale connectivity crucially underlies the structure, proper functioning, and failure of many complex socio-technical networks. For many decades, percolation was studied predominately as a second-order phase transition where at the critical threshold, the order parameter increases in a rapid but continuous way. In 2009, an explosive, i.e. extremely rapid, transition was found for a network growth process where links compete for addition. This observation of "explosive percolation" started an enormous surge of analyzing explosive phenomena and their consequences. Many models are now shown to yield discontinuous explosive percolation transitions, and some models exhibit a hybrid transition with a combination of second- and first- order features. Important mechanisms that achieve the required delay for explosive transitions include history dependence, non-self-averaging, and strong correlations. In this tutorial we will start to review standard percolation and end with "explosive phenomena" in networked systems. Examples include social systems, globalization, and the emergence of molecular life [D'Souza, Gomez-Gardenes, Nagler, Arenas, Explosive phenomena in complex networks, Advances in Physics 68(3):123, 2019]. We will close with some recent publication that provides a unifying framework for continuous, discontinuous and even hybrid phase transitions [Fan, Meng, Liu, Saberi, Kurths, Nagler, Universal gap scaling in percolation, Nature Physics, in press].

Tutorial TUT 2.3 Sun 17:40 HSZ 03

Spreading dynamics on networks: from social interactions to epidemics and pandemics — •Fakhteh Ghanbarnejad — Sharif University of Technology, Tehran, Iran

Spreading of gossips, news, infectious diseases, computer viruses, new products, etc. are some examples of epidemic dynamics. In this tutorial, firstly we review the basic models for modelling such phenomena including deterministic and stochastic approaches. Also we address how social contacts and the underlying topology of interactions can affect the dynamics. Finally we discuss when and how a spreading dynamics may end to a widespread endemic or pandemic and if and how social interactions play a role.