

## **DESCRIPTION FOR THE GENERAL PUBLIC**

The vast majority of systems encountered in our life remain out of equilibrium. It applies both to natural phenomena like chemical reactions, epidemic spreading, or interspecific competitions as well as those artificial ones, driven by humans, like stock quotes, traffic flows, or diffusion of innovations. In general, all processes in which a macroscopic net flux of some quantity is present are considered to be out of equilibrium. Although so common, these phenomena are poorly understood, and they go far beyond the scope of well-established classical thermodynamics which deals with equilibrated systems. Phase transitions, scaling and universality are essential concepts embedded in the theory of equilibrium statistical mechanics; thus, the legitimacy of their application to non-equilibrium models has been called into question. In fact, a general theoretical framework for physics out of equilibrium has not been provided yet.

Critical phenomena in non-equilibrium systems are even less explored and comprehended although they are of particular interest from the physical point of view. In classical thermodynamics, due to long-range correlations at criticality, microscopic components of a system act collectively displaying emergent behavior which depends primarily on the dimensionality of space and order parameter. All other characteristics become irrelevant, in some sense. This allows us to categorize phase transitions into several universality classes so that models within one share the same dynamics near the critical point. Systems out of equilibrium, on the other hand, without constraints in the form of detailed balance and reversibility exhibit richer critical behavior and are more difficult to classify.

Within the project, we are going to explore the frontiers of non-equilibrium physics and critical phenomena on complex networks which may represent a wide variety of systems. From power grids and transportation frameworks, through metabolic chains and biological dependencies, to the Internet and social structures. We aim at identifying network characteristics and microscopic dynamical details which have predominant influence on the critical behavior of non-equilibrium models and quantifying their impact. In the study, we plan to consider systems with two types of disorder, quenched and annealed, which reflect different time scales and rates of variation. Additionally, they introduce inhomogeneity into the system imitating external fluctuations, structural changes, or impurities in real environments. Due to interdisciplinary character of the research, the results will not only contribute to a deeper understanding of the differences between equilibrium and out of equilibrium statistical mechanics but also may find many applications across different disciplines.