

Physical Colloquium

„Macroscopic stochastic thermodynamics“

Prof. Dr. Massimiliano Esposito
Complex Systems and Statistical Mechanics,
University of Luxembourg



Honorary colloquium for Andreas Engel on
Monday, 24.11.2025, 2.15 p.m.
Room No. W02 1-148

Equilibrium thermodynamics emerges from equilibrium statistical mechanics as the most likely behavior of a system in the macroscopic limit. Over the last two decades, significant progress has been made in formulating statistical mechanics for small systems operating far-from-equilibrium. The resulting theory is often called stochastic thermodynamics. I will show that by taking the macroscopic limit of stochastic thermodynamics, one can formulate a nonequilibrium thermodynamics for large systems, typically described by nonlinear deterministic dynamics and macroscopic fluctuations around it [1]. This macroscopic stochastic thermodynamics gives rise to novel fundamental results. For instance, one can bound nonequilibrium steady state fluctuations using the entropy production along deterministic relaxation trajectories [2]. Many classical phenomenological results from macroscopic irreversible thermodynamics are also recovered within well controlled approximations. This theory opens the way to study the energetics of many complex nonlinear phenomena in a broad range of systems, such as chemical reaction networks (CRNs), nonlinear electrical circuits, and Potts models.

References:

- [1] G. Falasco and M. Esposito, "Macroscopic stochastic thermodynamics", Rev. Mod. Phys. 97, 015002 (2025).
- [2] N. Freitas and M. Esposito, "Emergent second law for non-equilibrium steady states", Nature Communications 13, 5084 (2022).

Host: Prof. Dr. Niklas Nilius

