DY 1: Tutorial: Non-Equilibrium Dynamics

Classical thermodynamics deals with systems in (quasi) equilibrium. However, due to external energy supply or removal a system can be driven out of equilibrium. As a consequence the behavior of these systems differs in several respects from those in classical thermodynamics.

This tutorial is intended to give especially young scientists the opportunity to learn more about the subject of non-equilibrium processes. Besides the introduction to some fundamental concepts several example systems will be discussed.

Time: Sunday 16:00–18:15 Location: HSZ 105

Tutorial DY 1.1 Sun 16:00 HSZ 105

Nonlinear deterministic and nonlinear stochastic processes as models in non-equilibrium physics — •Holger Kantz — Max Planck Institute for the Physics of Complex Systems, Dresden, Germany

Due to friction, every macroscopic system eventually enters a rest state unless it is externally driven. Whereas purely constant or periodic driving leads us to deterministic models, additional coupling to a heat bath results in non-equilibrium stochastic processes. This tutorial, to be understood in conjunction with the two other talks given by H. Stark and U. Seiffert, tries to cover the most relevant and most striking aspects of low-dimensional deterministic and stochastic dynamics of driven systems: bifurcations, lack of a superposition principle, self-organisation, and the interpretation as an entropy producing/exporting system.

Tutorial DY 1.2 Sun 16:45 HSZ 105

Stochastic Thermodynamics — •Udo Seifert — II. Institut für Theoretische Physik, Universität Stuttgart, Germany

In this talk, I will give an introduction to the emerging field of stochastic thermodynamics and illustrate its main concepts with recent experimental data. Stochastic thermodynamics provides a framework for describing small systems embedded in a heat bath and externally driven to non-equilibrium [1]. Examples are colloidal particles in time-dependent optical traps, single biomolecules manipulated by optical tweezers or AFM tips, and motor proteins driven by ATP excess. The notions of classical thermodynamics like applied work, exchanged heat and total entropy production valid there on the ensemble level can now be consistently identified and measured on the level of an individual stochastic trajectory. Moreover, exact results that refine the second law like the Jarzynski relation and fluctuation theorems for entropy production can be proven. Using these concepts, the efficiency of nanoscopic machines like molecular motors can be determined and their performance be optimized.

[1] U. Seifert, Rep. Prog. Phys. 75, 126001, 2012.

Tutorial DY 1.3 Sun 17:30 HSZ 105

Active motion at low Reynolds number — •Holger Stark — Institut für Theoretische Physik, TU Berlin, D-10623 Berlin, Germany

Starlings over Rome form dynamic swarms, fishes in water move collectively in fish schools. Zooming from the macroscopic into the microscopic world, bacteria also show intricate collective behavior.

However, on the micron scale swimming in aqueous environment requires different strategies than in the macroscopic world since at low Reynolds number drifting by inertia is not possible. Biological swimmers like bacteria and artificial microswimmers constantly consume energy to move forward. They are always in nonequilibrium.

The talk demonstrates some swimming strategies from nature but also of man-made microswimmers. It then illustrates at a few examples, how active motion reveals itself already on the single-swimmer level but also in the collective properties when many swimmers interact.