Adam Mickiewicz University in Poznań

Doctoral School of Exact Sciences AMU

Stochastic thermodynamics. From artificial to biological systems

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Field of science	Physics
Teaching method	Lecture, seminar
Language	English (or Polish)
Numbers of hours	20
Aims of the course	1. Brief introduction to stochastic processes motivated by thermodynamics. 2. Application of an extended form of thermodynamics to small fluctuating systems such as Brownian (colloidal) particles, molecular motors and biological molecules in living systems, and optionally mesoscopic quantum dots. 3. New interpretation of thermodynamic quantities like heat, work and entropy in stochastic fluctuating systems. 4. Formulation of fluctuation theorems. 5. Brief survey of information thermodynamics.
Course contents	1. Stochastic processes on discrete states and in continuous space (Langevin systems): Chapman-Kolmogorov equation, continuous-time Markov jump processes, Langevin and Fokker-Planck equations. 2. Heat, work and entropy in small stochastic systems, Shannon vs. stochastic entropy. 3. Equalities in stochastic thermodynamics: fluctuation theorems and the Jarzynski relation, derivation from Hamiltonian systems 4. The second law of thermodynamics, fluctuation-dissipation theorem and the Onsager reciprocity theorem from the fluctuation theorem. 5. Role of information in thermodynamic processes with measurement and feedback operations: the Maxwell demon problem. 6. Toy models of nanoscopic systems: flashing ratchet, Feynman ratchet, Brownian motor, energy and entropy landscape of a protein, kinematics and dynamics of enzyme action.
Prerequisites and co-requisites	Foundations of conventional thermodynamics and statistical physics

Learning outcomes	

On completion of the course PhD candidates will be able to:	Assessment mode
1. use the formalism of stochastic thermodynamics E_W01 P8S_WG 2. understand the meaning of fundamental concepts of stochastic thermodynamics E_W02 P8S_WG, E_U01 P8S_UW, E_K01 P8S_KK 3. describe the basic toy models of nanoscopic systems E_W02 P8S_UW, E_K01 P8S_KK	Writing exam or preparation and presentation of seminar

Literature	
Additional information	1. There are no books on stochastic thermodynamics available in the department library, so the literature will be recommended by the lecturer during the course. 2. The course content is only a preliminary proposal, therefore, the lecturer reserves right to make slight changes to it depending on needs.