

MULTISCALE THERMODYNAMICS: A THEORY OF RELATIONS AMONG MESOSCOPIC DYNAMICAL MODELS OF COMPLEX SYSTEMS

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ABSTRACT

Thermodynamics in a general sense [1],[2] is a theory of relations among mesoscopic dynamical models of complex systems. Models involving less details are related to (are reduced from) models involving more details. The reduction process is a pattern recognition process in which the phase portrait (collection of solutions) of the reduced model is recognized as a pattern in the phase portrait of the model involving more details. Thermodynamics is thus a meta-physics since it is a theory of theories. Reduction of a mesoscopic dynamical theory to equilibrium thermodynamics brings to the latter theory the fundamental thermodynamic relation (i.e. entropy as a function of the thermodynamic state variables). The reduction is made by following the mesoscopic time evolution to its conclusion, i.e. to fixed points at which the time evolution ceases to continue. The approach to fixed points is driven by entropy that, if evaluated at the fixed points, becomes the thermodynamic entropy. Since the fixed points are parametrized by the thermodynamic state variables (by constants of motion), the thermodynamic entropy arises as a function of the thermodynamic state variables and thus the final outcome of the reduction is the fundamental thermodynamic relation.

This reduction process extends also to reductions in open systems in which the reduced theory still involves the time evolution (e.g. reduction of kinetic theory to hydrodynamics). The essence of the extension is the replacement of the mesoscopic time evolution of the state variables with the corresponding to it mesoscopic time evolution of the vector field (i.e. of the fluxes). The fixed point in this flux time evolution is the vector field generating the reduced mesoscopic time evolution. The flux-entropy driving the flux time evolution becomes, if evaluated at the fixed point, the flux fundamental thermodynamic relation in the reduced dynamical theory. We show that the flux-entropy is a potential related to the entropy production.

Keywords: mesoscopic time evolution, open complex systems, thermodynamics

Reference:

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- [2] Pavelka M, Klika V, Grmela M. Multiscale Thermo-Dynamics. De Gruyter (Berlin); 2018.