## Understanding Thermodynamics of Small Systems within the Theory of Coarse-Graining

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In this work we use the theory of coarse graining to describe thermodynamics of small systems. The theory of coarsegraining, also known as Non-Equilibrium Statistical Mechanics, is a very general framework for the construction of coarse-grained (CG) descriptions of molecular systems. We show that thermodynamics can be understood as just a particular CG level of description of the system: the one in which the CG variables are the coarsest possible ones. The goal of this work is to illustrate how one can derive thermodynamics from the theory of coarse-graining in the particular case of a gas enclosed in a piston, subjected to an external force and in contact with a heat bath. This paradigmatic example is at the origin of the foundations of thermodynamics, and it is treated here in such a way that issues like time evolution, small system size, inclusion of thermal fluctuations, Green-Kubo transport coefficients, and microscopic expressions for work, heat, etc., are clearly exposed. One of the fundamental problems of thermodynamics is the prediction of the values of the extensive variables when some internal constraint in the system is removed. In the light of the theory of coarse graining, we will not only answer to the question of what is the final distribution of extensive variables in each system, but also to the interesting question of how the approach towards this final state occurs, giving the (stochastic) dynamic equations for the evolution of the (extensive) CG variables of thermodynamics.