Equilibrium States in Systems with Two Types of Temperatures

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Systems characterized by more than one temperature usually appear in nonequilibrium statistical mechanics. In some cases, e.g., glasses, there is a temperature at which fast variables become thermalized, and another one, associated with modes that evolve towards an equilibrium state in a very slow way. Recently, it was shown that a system of vortices interacting repulsively, considered as an appropriate model for type-II superconductors, presents an equilibrium state characterized by two temperatures. The main novelty concerns the fact that apart from the usual temperature T, related to fluctuations in particle velocities, an additional temperature θ was introduced, associated with fluctuations in particle positions. Since they present physically distinct characteristics, the system may reach an equilibrium state, characterized by finite and different values of these temperatures. In this talk, a general situation, concerning a system characterized by two distinct temperatures θ_{1} and θ_{2}, will be discussed. These temperatures appear as coefficients of different diffusion contributions of a nonlinear Fokker-Planck equation. An H-theorem is proven, relating such a Fokker-Planck equation to a sum of two entropic forms, each of them associated with a given diffusion term; as a consequence, the corresponding stationary state may be considered as an equilibrium state, characterized by two temperatures. One of the conditions for such a state to occur is that the different temperature parameters, θ_{1} and θ_{2}, should be thermodynamically conjugated to distinct entropic forms, S_{1} and S_{2}, respectively. A functional $\Lambda[P] \equiv \Lambda (S_{1}[P],S_{2}[P])$ is introduced, which presents properties characteristic of an entropic form; moreover, a thermodynamically conjugated temperature parameter $\gamma(\theta_{1},\theta_{2})$ can be consistently defined, so that an alternative physical description is proposed in terms of these pair of variables. The physical consequences, and particularly, the fact that the equilibrium-state distribution, obtained from the Fokker-Planck equation, should coincide with the one from entropy extremization, are discussed.