How to reconcile Information theory and Gibbs-Hertz entropy for inverted populated systems

Abstract:
In this paper we discuss about the validity of the Shannon entropy functional in connection with the correct Gibbs-Hertz probability distribution function. We show that there is no contradiction in using the Shannon-Gibbs functional and restate the validity of information theory applied to equilibrium statistical mechanics. We show that under these assumptions, entropy is always a monotone function of energy, irrespective to the shape of the density of states, leading always to positive temperatures even in the case of inverted population systems. In the second part we assume the validity of the Shannon entropy and thermodynamic temperature, $T = \frac{dE}{dS}$, extended to systems under non-equilibrium steady state. Contrary to equilibrium, we discuss the possibility and meaning of a negative temperature in this case. Finally we discuss on Carnot cycles operating with a non-equilibrium bath possessing a negative temperature and leading to apparent efficiencies larger than one, due to a wrong accounting of all the energy and entropy fluxes present in the system, including the external driving forces.
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